THE OHIO JOURNAL OF SCIENCE

Vol. 59 JULY, 1959 No. 4

SCENES IN OHIO DURING THE LAST ICE AGE†

RICHARD P. GOLDTHWAIT

Department of Geology, The Ohio State University, Columbus 10, Ohio

During the last decade more than a dozen geologists and some pedologists and botanists have tackled the surficial deposits of western Ohio for a reinterpretation of Ice Age history. This was first deciphered in detail at the turn of the century by Leverett (1902). The new ideas are embodied in the new Glacial Map of United States East of the Rocky Mountains (Geological Society of America, 1959) and a forthcoming Glacial Map of Ohio (U. S. Geological Survey). During this same decade the young science of glaciology has mushroomed due to military studies of polar ice caps and to the International Geophysical Year. It seems entirely appropriate to put these together; in short, what can today's ice caps tell us of Ice Age events? The most complete record in surficial deposits is that of the very last Ice Age, the classical Wisconsin Stage. What was this last North American ice cap like?

This application of glaciology to Wisconsin Stage history follows the principle of uniformitarianism. It is held that whatever took place in Ohio 9,000 to 30,000 yr ago is taking place somewhere in the world today. Several specific assumptions are involved: (1) Major weather conditions in Wisconsin time over the ice sheet in North America were essentially like those today over the much smaller ice caps at higher latitude. Climatic zones were squeezed together, thus intensifying winds, over mid-latitudes like Ohio, but the same storms we have today must have delivered snow to the former ice cap. (2) Glacial ice flowed in essentially the same fashion 20,000 yr ago as it does today. This is implicit in the similar stress values at the bottom of a great variety of arctic and temperate glaciers as calculated recently (Goldthwait, 1957). (3) Topographies similar to Ohio can be found under Malaspina Glacier in Alaska, in some broad valley areas of Glacier Bay; so, these affect ice today much as Ohio topography affected Wisconsin ice. (4) Radiocarbon measurements of time, so numerous in Ohio, are essentially correct at least as to relative order. They are internally consistant in Ohio, albeit different from the preconceived conventional pattern.

Advance of the Last Ice into Ohio

Conditions near the ice edge.—In many spots near the outer part of an ice sheet, the glacier covered but did not destroy the prior land surface; so, there is some record of the terrain into which the ice moved. The deposits near Cleveland show it was a lake dammed before advancing ice (White, 1953); carbonaceous alluvium at Hamilton suggests it was a flood plain; rotted till at Brush Creek suggests it was swampy (Forsyth, in preparation); and at several other exposures there is very thin buried forest soil (Goldthwait, 1958). Each of these surfaces is on earlier glacial drift. The surface was and is gently undulating or flat just as would be the case if ice were to spread over Ohio today; the deep preglacial bedrock valleys were already filled by glacial deposits.

†Presidential Address delivered at the 68th Annual Meeting of The Ohio Academy of Science, at Capital University, Bexley, Ohio, April 17, 1959.

The environment was different as regards vegetation and climate, however. Laid out on the paleosol at Sidney (LaRocque and Forsyth, 1957) and in the lake at Cleveland are spruce logs (fig. 1). The forest litter at Oxford contains spruce needles, cones, and fly wings. At 15 places now similarly-dated spruce wood has been found within the upper glacial till. These involve hundreds of logs,

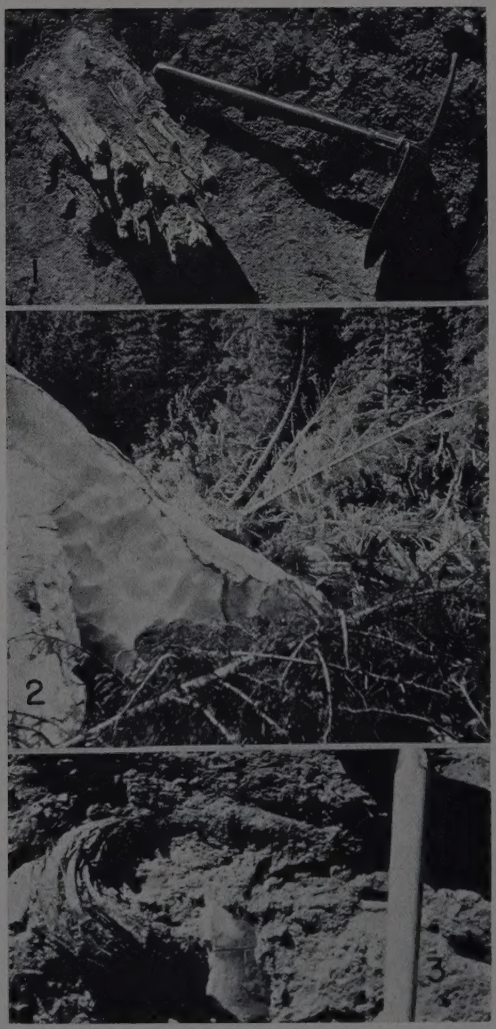


FIGURE 1. Spruce log lying on a buried soil and covered by calcareous blue-gray till at B & O Railroad cut south of Sidney, Ohio. The log is 23,000 yr old.
FIGURE 2. Taku Glacier invading forest of Sitka Spruce in Alaska. Photo by W. O. Field, This was the scene from 19,000 to 25,000 yr ago in Ohio.
FIGURE 3. Bent spruce log with bark buried in glacial till at Biers Run, Chillicothe, Ohio.

sometimes packed together in great profusion (fig. 2). These trees evidently were alive when ice mowed them down because some were bent double without breaking, and many still retain tight bark (fig. 3). Old dead logs snap when bent. The spotty grouping of many logs suggests that these trees were in patches or perhaps prolific along streams. As Martin (1959) has recently deduced, the tree size suggests a taiga or open forest type of association, such as is now found at Knob Lake near 54° North Lat. in Quebec (fig. 4). If identical, the mean annual temperature then was 23°F which is 30° cooler than is Columbus today (table 1). More likely the warmest month was like July at Knob Lake, mean daily temperature near 55°F. It may be fair to surmise that, as the ice approached, July temperatures in central Ohio were about 20° cooler than today.

Precipitation probably was heavier because the glacier had to be well-fed with snow. Nevertheless, in comparable forest environment at Knob Lake, mean annual precipitation is only 32 in.; but Juneau surrounded by active glaciers gets 83 in. annually. The large ice masses at lowest latitudes today receive 60 to 110 in. on their upper surfaces (Ahlmann, 1939; Diamond, 1958; Sharp, 1951). Although Ahlmann's original studies (1940) blamed temperature mostly for glacier fluctuations, more and more glacial budget studies place the emphasis of glacier size on the amount of actual snowfall rather than on low temperatures per se.

TABLE 1

Today's climate where the glacier used to be

	Mean daily temperature			Mean annual precipitation	
	Annual	January	July	All kinds	Snowfall
Former ice source areas in Canada					
Knob Lake Area	23°F	−11°F	55°F	32 in.	121 in.
L. Mistassini Area	31°	− 6°	60°	35 in.	122 in.
North Bay Area	38°	10°	67°	33 in.	81 in.
London, Ontario Area	47°	22°	70°	35 in.	40 in.
Former glaciated areas in Ohio					
Cleveland, Ohio Area	51°	28°	73°	32 in.	36 in.
Columbus, Ohio Area	53°	30°	75°	37 in.	16 in.
Hamilton, Ohio Area	54°	32°	76°	40 in.	15 in.

How the ice spread.—Wherever the last ice went, it spread the ubiquitous glacial *till* which is found in back yards in 63 counties in Ohio (fig. 5). To the relatively smooth earlier glacial deposits, it simply added a veneer of till one to 90 ft thick (fine rock-flour, silt, sand, pebbles and subangular stones all mixed). There is reason to believe that this till was smeared down from beneath moving ice (fig. 6) because laborious "till fabric" measurements in a dozen places in Ohio show that the long axes of most stones trend in one preferred direction (Holmes, 1941). Perhaps stones were oriented by shearing in basal ice which melted from below as it stopped flowing (Harrison, 1957). In cold arctic ice, studied in tunnels in northwest Greenland, the glacier is solidly frozen to the ground and all glacier motion takes place within the ice one to 30 ft above the ground (Goldthwait, 1957). But the Ohio glacier was just like warmer Alpine glaciers, in which as much as 50 percent of the motion has been shown to be due to slipping at the very sole of the glacier (Sharp, 1954). It is logical to think of water lubricating this base, first because evidence presented later shows that the ground was not frozen; so, internal earth's heat may have melted the sole. Second, meltwater is heavier than ice and in these warm marginal areas it could have forced its way hydrostatically from crevasses to the basal ice. Third, great rivers issue even in winter from under the ice cap in south Greenland; so, melting at the base must be continuous.

The source of most of this ice lay northeast of Lake Erie and north of Toronto, perhaps near Lake Simco and the Quebec-Ontario boundary or a little farther north. Between two and 25 percent of the pebbles counted in till of western

Ohio are crystalline quartzites, granites, diorites, schists, most of which can be found in this Ontario area. Among the sedimentary rocks in the till of western Ohio are persistent black limestones (one percent) which match the Ordovician belt north of Toronto. We know of no rocks yet which require ice flow from much farther north. Dreimanis and Terasmae (1958) show that the first motion at Toronto (their "middle till") was westward along the axis of Lake Ontario; so, the ice to the north of Lake Erie shunted southwestward into western Ohio.

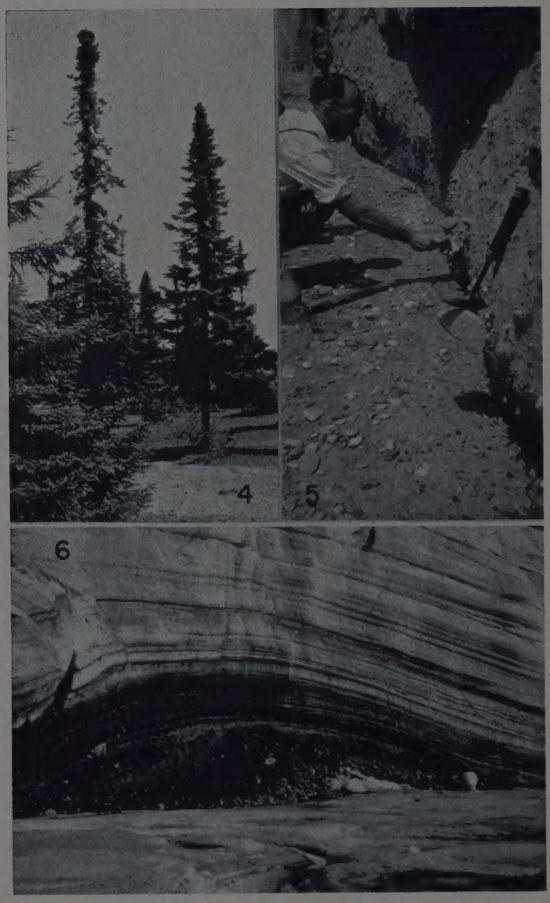


FIGURE 4. Present-day spruce forest near Goose Bay, Labrador, like those in Ohio when the last ice invaded.

FIGURE 5. Glacial till made of boulders, stones, sand, silt, and rock flour and exposed along the north shore of Lake Erie by waves. Pebbles in this till have preferred orientation or "fabric."

FIGURE 6. Glacial till carried at the base of an outlet glacier (South Twin) of the Greenland Ice Cap. A stream has undermined this ice exposing dirt along shear planes over a mound of till already deposited.

These suggest that ice probably started across Lake Erie as a sheet of grounded ice, perhaps 600 ft thick like parts of Ross Ice Shelf in Antarctica.

One of the most obvious features is the lobes into which the ice flow was divided by high bedrock areas such as the Bellefontaine Outlier. This was recognized by the earliest workers (Chamberlain, 1882) from the outlines of terminal moraines (fig. 7). The striae suggest one main stream, the Miami lobe, down through Miami and Montgomery Counties, and another, the Scioto lobe,

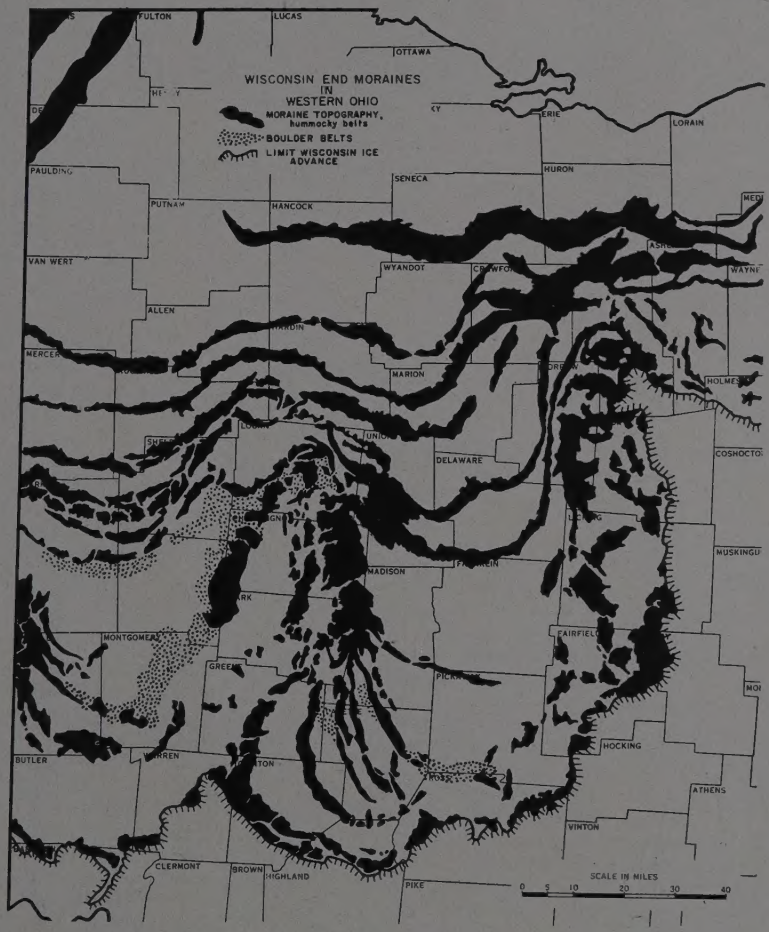


FIGURE 7. Wisconsin end moraines in western Ohio.

down through Delaware and Franklin Counties. The intervening bedrock area above 1,300 ft was covered with thinner ice and probably the streaming was evident on the snow-ice surface as it is in Antarctica today (Apfel, 1952). Later, when the glacier melted away, these marginal lobes became even more deeply lobate.

Now we have good clues as to how fast the ice spread over Ohio. Burns

(1958) estimates from the gradual decrease of ring width over the last 70 yr of the life of buried logs at five localities, coupled with observations in British Columbia showing that trees up to one-half mile away are affected by advancing mountain glaciers, that the ice edge advanced at a rate on the order of 38 ft per year in Butler and Ross Counties. Carbon[14] dates of these same buried logs afford an entirely independent estimate of advance; in lower Scioto lobe, these make the advance average 55 ft per year, and in Miami lobe it averaged 108 ft per year. Advance from the lake near Cleveland to central Ohio was much faster, averaging near 390 ft per year to Sidney and 310 ft per year to Columbus (Goldthwait, 1958).

Glacial studies suggest that these rates are reasonable but do not prove them. Since most glaciers have been in retreat for the last half century, it is hard to find any that have advanced consistantly for many decades. Taku Glacier in

TABLE 2

Various Wisconsin datings suggested for central United States

Radiocarbon years ago	Iowa (Ruhe, Rubin and Scholtes, 1957)	Illinois-Indiana (Horberg, 1955)	Illinois-Indiana (Hough, 1958)	Ontario (Dreimanis and Terasmae, 1958)
Before 38,000			Farmdale Iowan	early Wisconsin
Before 30,000	Iowan		Bloomington	
28,000				
26,000		Farmdale	Cary	
24,000	Farmdale	Iowan		
22,000		Tazewell		main Wisconsin
20,000				
18,000				
16,000	Tazewell	(Brady)		
			Port Huron	
14,000	Cary			
		Cary		
12,000				
	(Two Creeks)			(Two Creeks)
10,000			Valders	Valders

a broad valley in southeast Alaska has extended 350 ft per year since last century (fig. 2); until the last decade this glacier ended in water, which may have speeded its advance. North Ice Cap, north of Thule, Greenland, has advanced only two ft per year over patterned ground for some time (fig. 8). Vegetation 100 ft back under the ice was less than 200 yr old (W–532), suggesting only one-half foot gain each year. The Vatnajokull in Iceland is reputed to have expanded up to one mile in a century (Thorarinsson, 1943). At least these rates and dozens of similar ones in modern valley glaciers (Field and others, 1958) show how reasonable the Ohio figures are.

Correlation with adjacent states.—The gradual progress of the ice edge southward across Ohio does not correlate directly at first glance with C^{14} dated advances and retreats to the west (table 2). The total advance occurred between 24,600 and 16,600 yr ago, if outside C^{14} dates in Ohio are reliable; within this period occur all of the classical substages in Illinois (Horberg, 1955) and most of them in Iowa (Ruhe, Rubin, and Scholtes, 1957). It is evident from table 2 that Farmdale advance or Iowan, plus Tazewell and its late phase, Bloomington, were all equivalent to this one advance over Ohio; it is logical that the interstadials represented some halting and even recession in Ohio too. Ice was just moving into Ohio 25,000 yr ago and this tallies with some Iowan dates in Iowa. Fossil molluscs in the windblown loess below the lake beds at Cleveland (Leonard, 1953) suggest a similar correlation for they are like Iowan types in Kansas and the Mississippi

Valley. So far the longest gap in C^{14} dates is 1,600 yr (24,600 to 23,000) and at the end ice was in central Ohio. The slow push to outer Wisconsin terminal moraine in Ohio correlates best by C^{14} with either Bloomington Moraine (late Tazewell) or earliest Cary, depending upon a precision which the C^{14} dates do not afford.

Climax of Glaciation

Different dates on different lobes.—The several lobes in Ohio reached their maximum positions at dates 1,400 yr apart. The Wisconsin Glacier was ploughing logs into the terminal moraine in Miami lobe as far back as about 19,500 yr ago (W–304 Westchester and W–724 or W–738 Hamilton) whereas the ice of Scioto lobe emplaced logs in end moraine 18,100 yr ago (Y–448 Cuba, W–91 Chillicothe, W–331 Anderson). The standard error in these figures (±400 yr) does not account for this difference. In addition, the moraine pattern (fig. 7) suggests that Scioto lobe moraines in Warren County cross Miami lobe moraine trends; so, the outermost push of Scioto lobe came later. This means that some interlobate areas may have been invaded first from one side, then from the other; in Greene County there are glacial striae both from the northwest and the northeast on the same ledges.

This shifting flow is analogous to recent alternations in Greenland. A few centuries past, the main Greenland Ice Cap advanced several miles overland covered by well-formed patterned soils. Now it is receding, but the contiguous small North Ice Cap is advancing into the same intervening area. Why? The best guess is that sea surfaces, recently freed of summer ice by a rise in temperature, supply more moisture for snow on the coastal North Cap (Goldthwait, 1957) than did pack ice.

Sources of ice supply and motion.—How wide was the zone of bare ice on the Wisconsin Glacier in which all winter snow melted each year? Ahlmann (1939) found that modern Vatnajokull in the cool wet Atlantic atmosphere has an accumulation limit some 16 mi back from the southern edge. In south Greenland, although studies are few, the snow melts for at least 45 mi up onto the ice cap (Holmes, 1955). These should be a minimum measure for the still bigger Wisconsin ice sheet at its southern limit. One might postulate a 50-mi wide zone of completely melting snow so that exposed glacier ice stretched from Chillicothe to over Columbus each summer and from the northern suburbs of Cincinnati to over Dayton, Ohio (fig. 9). Over the rest, snow accumulated faster through the year than it was melted in summer. One main center of gathering snow may have been the ice surface over Lake Erie Basin.

This does not mean that ice did not gather and flow at the same time from eastern Ontario. In fact, the small percentage (ten percent) of crystalline pebbles and minerals at all levels in Ohio till (and a much greater percentage of fines known in Indiana tills) certifies that some ice did come from there. As for Antarctica and Greenland today, there are main streamlines of flow outward from central parts of the ice sheet; on these are superimposed the local fluctuations of snowfall and drifting as surface ice creeps forward at one to 30 in. a day (Schytt, 1955; White, 1956). Motion measurements in Greenland are so slow that if applied to the Ice Age snow falling in Quebec this ice would never have reached Ohio by the demise of the Wisconsin Glacier. Evidently it moved faster in main streams. Snow landing over the Erie Basin took less than 1,000 yr to reach the heavy melting zone near Columbus or Dayton and moved at least two ft a day on the high surface in order to advance the ice margin 350 ft per year even while it melted.

This is not entirely speculation. Careful studies of the deep grooves in Ohio's bedrock and prominent crag and tail (fig. 10), which certainly require many abrading tools and many miles of ice-flow to shape them, indicate that these are concentrated under the former center of each ice lobe and flare outward only slightly to the very outermost terminal Wisconsin position. The grooves on

Kelley's Island imply extremely fast flowing ice. In other words, deep abrasion was accomplished where the ice was deepest and flowed farthest. Sharply radiating fine striae were made during thinning ice of later stages for, at the margins of lobes, these aim across the high parts of deep engravings and locally are perpendicular to recessional moraines.

Depth of the ice.—This has always been a fascinating unknown. As our information about Greenland and Antarctica grows, more analogies become available. In Antarctica, over hilly surface as rough as eastern Ohio, the snow surface is about 1,500 to 4,900 ft above the edge 50 mi back from the sea at a dozen places (USNC–IGY Map of Antarctica, 1958). In Greenland snow 50 mi back is 3,000 to 5,000 ft above the ice edge (fig. 11) but the land is more mountainous (Victor, 1953; Holmes, 1955). Vatnajokull, Iceland, lies on low hills comparable to Ohio and it is 4,400 ft high within 50 mi of the ice edge. As much as 200 mi up onto inland ice in Greenland and Antarctica the surface averages 6,400 ft above the ice edge. Until more comparable cases are available, we might estimate 3,000 ft for the depth of ice formerly over Columbus or Dayton, and at least a 5,000-ft depth of ice over Lake Erie Basin.

One direct method tells us a little of the steepness of the ice edge itself. All glaciers fit themselves by solid flow to the topography (fig. 12). In the hills of the escarpment in Ross, Fairfield, and Licking Counties, and in Northeastern Ohio, small ice tongues projected between the hills and far down the larger valleys. Detailed mapping of soils along some hillsides suggests that the slope of the ice edge was at least 100 ft per mile in some of these bulging marginal areas (fig. 13). Of course, this is a measure of the extended ice edge against the hills; the ice itself rises more than 200 ft in the first quarter mile from the margin in every active modern glacier.

It has long been the hope that the dual compression effects of ice load on top of till and the wetting and drying which compact till could be separated, so that depth of ice load might be calculated. This has not been accomplished yet (Harrison, 1957). Instead, study of the drift sheet does indicate something as to the depth of glacial erosion into the preglacial surface. Since all the loose soil, rubble and rock which were scraped off under the ice, was carried just a little way before redeposition, we can make a direct calculation. Stone counts and sand counts show average travel of two to five mi from the source area and the matrix seems to come from much farther. The average drift depth is 51 ft on the northern uplands (summary of 2,800 wells: VerSteeg, 1933). Detailed recent groundwater studies in western Ohio suggest similar depths for the most recent glacial drift (Water Division, Dept. of Natural Resources, county reports). If we assume, then, that enough extra drift was added through overall southward motion to offset the losses of fines which water carried away, then the ice left a net product about 50 ft deep. One study shows that in Minnesota some 40 percent of the till may be already stained mineral matter (Kruger, 1937). In other words, this was preglacially weathered soil which the glacier scraped up. If Kruger's figure is valid in Ohio, the drift would constitute an original soil layer not over 20 ft deep. If we reduce the remaining 30 ft to original rock density, it was an additional layer of solid rock 25 ft thick.

The change which turned the ice back.—What happened to the plants and animals all this time? Obviously in the area of the ice they were annihilated or driven south. On a botanical basis, Braun (1928) has shown that many which are not easy travelers (do not spread), like *Sullivantia*, must have lingered in protected colonies (refugia) on favorable southerly hillslopes near the ice—otherwise, why should they be clustered near the edge of Wisconsin till now that the ice is long gone? Thomas (1951) has shown that some salamanders and Orthoptera have ice-edge distribution and have moved northward only since glaciation. This is vigorously opposed by Deevey's concept (1949) of a wide tundra belt and ice age animals driven south to the Gulf Coast. However, no bog yet studied in Ohio

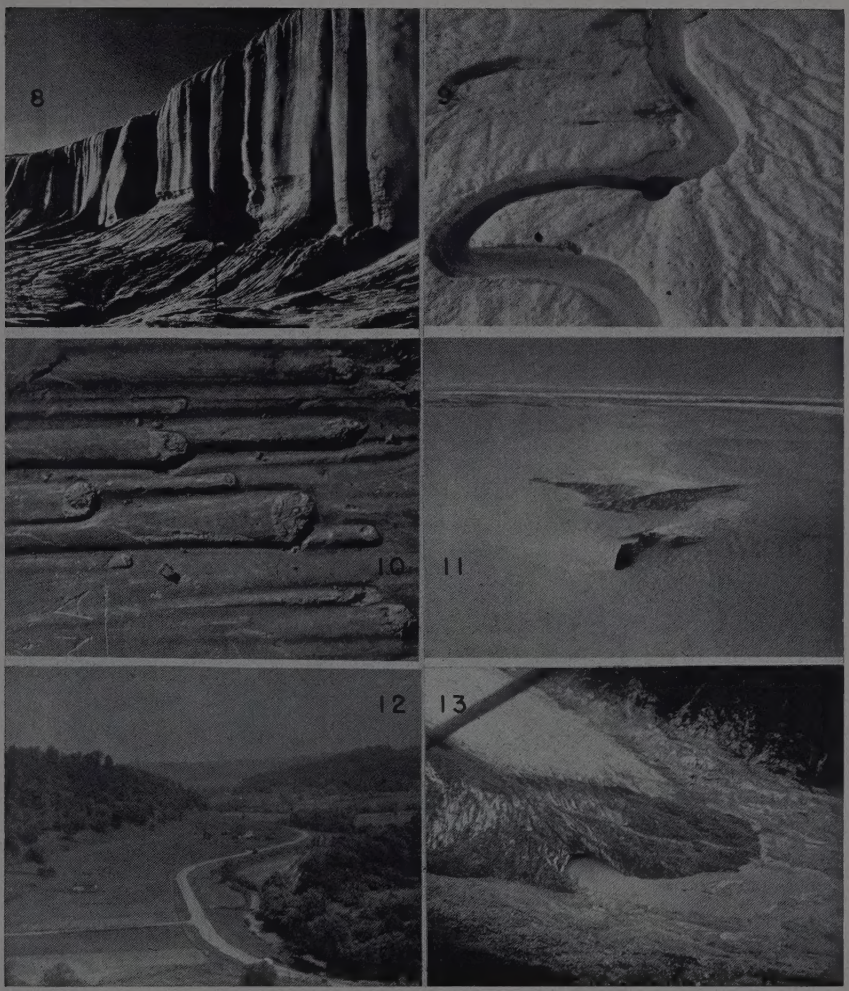


FIGURE 8. Cliff of slowly advancing ice on the east edge of North Ice Cap, Red Rock, Greenland. The ice may have looked like this, advancing over Ohio.

FIGURE 9. Exposed glacier ice where all winter snow melts off near the edge of the Greenland Ice Cap north of Thule. Rivers of meltwater cut the surface as they did in southern Ohio in Wisconsin time.

FIGURE 10. Prominent crag and tail ridges developed beneath the deep ice by abrasion across limestone ledges north of Columbus, Ohio. "Crags" are chert nodules in Columbus limestone. Photo by R. A. Keen.

FIGURE 11. Thirty miles out over the Greenland Ice Cap from Dundas. The ice surface over north central Ohio once looked like this except that no mountain peaks projected through.

FIGURE 12. Typical valley in the edge of the hilly parts of southeastern Ohio. Narrow lobes of ice projected a short way into each valley.

FIGURE 13. Modern glacier terminus, Ferebee Glacier in southeastern Alaska, projected down its valley as a lobate end much as the Wisconsin ice edge did in Ohio.

shows anything but tree pollen dominant at the base; so, I must believe that the spruce and hemlock grew in groups right at the ice edge and moved back over glaciated western Ohio as the ice left. That some mastodons wandered south to Louisiana for the winter is perfectly all right too!

Geological evidence indicates that the last ice sheet did recede in the face of a very mild climate. Subarctic tundra is underlain by permafrost; in patches it even comes into the wooded fringes. Wherever there is permafrost, patterned ground develops (fig. 14), and this in turn involves formation of vertical ice wedges and overturning by frost in the summer thaw zone (two to five ft deep). It is estimated that, in the 15 counties of western Ohio now mapped in detail, some 3,000 road, creek, and pit exposures of soil were inspected. Among these only one showed good possible convolutions (ice-twisted soil layers) and less than three had possible vague wedge structures. This indicates that permafrost was rare if it occurred at all; the nearest well-known obvious large late-glacial patterned structures are fossil forms at 5,000 ft elevation in New Hampshire and

FIGURE 14. Polygonal pattern of sorted soils accomplished by frost action in the thin upper "thaw zone" on top of frozen ground. Nunatarssuaq, Greenland.

New York (Antevs, 1932; Goldthwait, 1940). Lesser effects of intense seasonal frost action is observed on 2,000-ft Pennsylvania hills (Denny, 1956), and in all these cases the glacier ice was nearby. Deducing that permafrost conditions did exist nearly down to 4,000 ft, the mean annual temperature on Ohio's 1,000-ft high land was about 42°F, which is only 11° cooler than today.

By analogy again, what conditions have been required to drive back large modern glaciers during the last half century? In southern Iceland, near sea level, mean annual temperature is 39°F, and summer mean is 51°F. At Juneau, Alaska, nearest station to Glacier Bay, where glaciers have thinned a thousand feet, summers average 56°F. By analogy I believe that a temperature of at least 56°F prevailed during each July in Ohio to drive the ice out. (Winter does not matter for it was too cold in any case!)

Disappearance of The Ice

Decaying of the ice edge.—A glance at glacial maps of Ohio will show that the

marginal area, 10 to 20 mi wide, of this last Wisconsin ice sheet and especially the interlobate areas are characterized by ice-contact washed deposits (fig. 15). What does this mean?

Vast areas of similar deposits have been observed in the making today wherever two conditions are met: (1) rapid down melting and thinning of glacier ice, such that its flow is cut off or very sluggish; and (2) presence of hilly topography to cut off the flow and leave great spoon-shaped masses of detached ice. This second condition is met most of the way along the last ice border because it reached into the hills south and east of the Appalachian Escarpment (fig. 15). There are great concentrations of ice-contact deposits south of the high bedrock and interlobate area of Logan County. We can deduce that the last ice sheet began to disappear by rapid melting all over the surface and this produced wholesale thinning of the

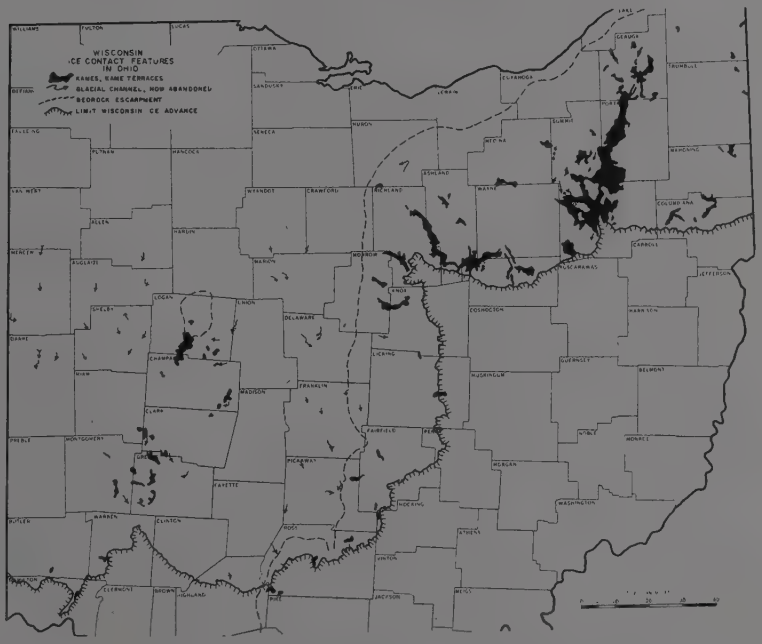


FIGURE 15. Wisconsin ice contact features in Ohio.

edges. Hills protruded near the edge, and thin ice became covered with dirt which had been near the base.

The outstanding deposit of such areas is the glacial *kame*. It is an irregular hummocky mound of layered sand and gravel—some coarse, some fine. Some layers are dirty (i.e., silty), but most layers have the silt and clay washed out. Huge boulders may be sprinkled through the deposit like raisins in rice pudding, and not uncommonly there are irregular blobs of till (fig. 16).

In four large valley areas where this is happening in Glacier Bay today, the dirt does not collect on the ice surface until the ice is nearly gone, for dirt is carried in the lower hundred feet of ice. Finally it collects from two to four ft thick on the last ice surface and protects it from melting for many years (fig. 17). In the meantime, meltwater and rain open a honeycomb of passages through the hidden blue ice beneath. Collapse of these passages and enlargement of the surface

entryways start the surface dirt sliding and washing into the pits (fig. 18). This develops large circular sink holes with pools in the ice. Floods of meltwater collect washed and half-washed sand or gravel at the bottom (fig. 19). Eventually the surrounding ice melts away and the deposit at the bottom of each former pool is left as a mound. Where decaying ice was previously high, there is now a trough; the topography of the decaying ice is preserved in reverse (fig. 20). Where

FIGURE 16. Pit excavation in glacial kame deposits of Southern Hills, Dayton, Ohio. Sandy gravel with cemented masses and boulders.

FIGURE 17. Remnant ice mass from decaying glacier covered with soggy dirt and accompanied by meltwater lakes which undermine the ice cliffs. East side, Muir Inlet, Alaska.

FIGURE 18. Decaying ice mass with section of old stream tunnel and cover of dirt. Muir Inlet, Alaska.

FIGURE 19. Funnel-shaped pits developed in dirt-covered glacier ice near the end of Tasman Glacier, New Zealand. In these pools sorted sandy gravel gathers to become kames.

FIGURE 20. Kame mounds of sandy gravel south of Akron, Ohio. These were deposited in summer in pools surrounded by dirty glacier ice.

FIGURE 21. Kame terrace built recently by streams depositing gravel between the ice on the right and the hillside on the left. Nunatarssuaq, Greenland.

the last buried ice slabs slowly melt out, funnel-shaped *kettle holes* develop in the gravels (fig. 30). Kames and kettles come together.

Sometimes a flat-topped shelf or terrace of sandy gravel lies on a hillside above a valley partly filled with kames. These are kame terraces formed in the early stages of kame accumulation where tumbling meltwater washed its full load into the trough between the down-wasting ice and a hillside already there. Later, when the ice melted, a shelf was left, complete with kettle holes and sloughed boulders, high and dry along the hillside (fig. 21). These are found in main valleys through the hills, especially in northeastern Ohio (fig. 15).

On nearby hillslopes associated with kames are short glacial *channels* cut along the hillside rather than directly downhill as any "sensible" stream would go. This is a common feature around decaying ice in hilly Alaska (fig. 22). There may be a dozen or more channels, 100 to 1,000 ft long and five to 50 ft deep, cut in till. It is clear from recently studied examples that dying ice fills the deep valley so that water along the valley wall trims the till away, first at one level and then at a lower level. No characteristic series of channels has yet been found, even in the hilly northeastern parts of Ohio; but there are many short abandoned channels over the lower plains, and especially through hummocky end moraines where the initial drainage was forced away from present courses by ice openings (fig. 23).

FIGURE 22. Glacial stream flowing along the margin of dirt-covered wasting ice (background). The meltwater is cutting a channel along what will become sloping hillside as the ice melts. Plateau Glacier, Muir Inlet, Alaska.

FIGURE 23. Old glacial channel in Logan County, Ohio. Water once flowed from right to left from the glacier to cut this valley.

Systematic northward melting.—Every large ice cap which has been retreating during the last half century has an extra broad zone of melting ice surface during each summer. In cold polar glaciers, like those in north Greenland, water cannot penetrate the cold ice (14°F) without refreezing; so, it passes over the surface in rivers. In lower latitudes, deep ice is just about at melting temperature. Here floods of meltwater pour into holes one to ten mi back from the margin. Thus, in retreating, the ice thins, melts from within, and melts back at the edge faster than motion supplies new ice to the edge. (Recent tunnel measurements show that small open tunnels under 100 to 200 ft of ice cover close at one-half to one ft per year from all sides and bigger rooms close at two or three ft per year [Rausch, 1958]. Water must reenlarge these natural tunnels each year.)

The only record of this sort of ice tunnel in Ohio is the random *esker* ridge which ends in or near a belt of end moraine (fig. 24). In living glaciers, passages in the upper ice are almost free of dirt, for all the dirt load of a glacier is concentrated in the lower ten to 200 ft of ice. Where gradient is low, it favors deposition of alternating layers of sorted sands and gravels. These deposits may get deeper until the tunnel floor is built up with a ribbon of gravel ten to 100 ft thick. Not all the streams in this dirty ice at the bottom of the glacier are depositing, either,

for some cut channels. For this reason the deposits may not be continuous. (This does not explain all eskers. Eskers in New England which climb up over a divide, or eskers that are continuous horseback ridges 50 mi long must have been made in hydrostatic pipe systems in the ice.)

The eight Ohio eskers are actually chains of ridge segments (fig. 27). We presume that the drainage system was all one long ice tube, since ridge segments lie end on end. Each esker contains layers of good water-washed sand and gravel dipping gently in every direction. Some have several tributaries, as in Delaware County where the esker involves parallel ridges. Another through Pickaway County has patches of till on the crest; these might have dropped from the ice roof. More difficult to explain is the four- to six-ft veneer of ice-laid till on the buried esker east of Columbus. This might mean that it was made under the edge of an earlier ice sheet, or the last ice sheet itself might have slid over its own esker after waters formed it.

A closely related form is the isolated high mound of sandy gravel erroneously referred to as an Indian Mound. However, these are up to a half mi in diameter and 50 to 200 ft high with carefully cross-bedded gravel—busy Indians! Actually, they are *moulin kames* standing above Ohio's plains (fig. 25 and 27).

Similar mounds were seen forming on Barnes Ice Cap, Baffin Island. Surface drainage plunges into a huge cylindrical hole half a mile back from the ice edge and over 200 ft deep. Apparently the water column has forced and melted its way out below, but torrents of meltwater swirling into the hole gathered dirt from the basal ice and piled it in the middle of the bottom like sugar in a coffee cup. Ten mi away a similar knob of gravel was melting out so its gravel slumped to an isolated chocolate drop-shaped pile (fig. 26).

Third and most extensive is the *outwash plain* or valley train. Wherever a glacier ends in a region which slopes away from the ice, the waters which issue from one or more tunnels in the ice edge head down the nearest valley lowland (fig. 28). Many million gallons are produced on warmest days. Coming from the basal ice, the water is milky with the rock flour of glacial till and it has a full bed load of sand and gravel (fig. 29). In fact, more tons of particles are fed into the stream at the glacier than ever reach the lake or sea; so, there must be constant addition to the surface or the plain. Some load is dropped on each bar, thus filling up the shallow channel and causing the water to spill over to the right or left and start an additional channel. All glacial outwash rivers become braided by dividing into many channels each ten to 100 ft wide and one to ten ft deep. The water runs nearly flush with the surface. Most of the coarsest cobble part of the load gets left on the first few upstream bars, but in their place the water gathers some smaller pebbles already there. There is constant exchange such that where the meltwater reaches its delta, it has a smaller load composed mostly of sand and silt. For this same reason, the gravelly upper part of the plain is steeper (over ten ft per mile) than the sandy lower part. When one side of the valley plain builds ten to 20 ft higher, the braided currents shift to the low side of the valley. The resulting "valley train" is smooth with only minor little scarps (five to 20 ft) and abandoned channels.

This was the scene in most south-flowing valleys in Ohio as the ice retreated (fig. 28). On the east and west walls of each valley, such as the Licking, the Hocking, the Scioto, or Miami River, there are steplike shelves of sand and gravel which at first glance look like kame terraces (fig. 30). Unlike kames, the shelf-tops match across valleys, indicating that they are the remnants of a once-continuous sandy gravel plain. Following glaciation, the meandering rivers have dug down and trimmed away central parts of these smooth glacial valley trains; much of the gravel is gone; yet, it is still our third richest underground resource material.

The glacial map of Ohio shows a large area of outwash from Logan County to Greene County in west central Ohio (fig. 27). This is not only Ohio's biggest outwash, and a superb drought-defeating source of groundwater, but it has no

FIGURE 24. Pit excavation follows a winding esker ridge which continues to the right in the distance near New Richland, Ohio. Photo by J. L. Forsyth.

FIGURE 25. Mound of layered sandy gravel, called a moulin kame, formed in a large hole in the former glacier ice east of Urbana, Ohio.

FIGURE 26. Moulin kame mound in the center melting out from the retreating southwest ice edge of Barnes Ice Cap, Baffin Island.

western valley wall' In fact, to explain its course, cutting from Mad River watershed through low hills to Little Miami watershed, we must presuppose an ice wall on the west which prevented its flow into Mad River and Miami Valleys. Verifying this hypothesis, there is ice-laid till pushed up from the northwest onto the high west side of this plain.

A second general feature of these outwashes is that most valleys contain not one but two or more persistent low levels of valley train. (Of course, the highest levels beyond the Wisconsin terminal limit have deep reddish soils and relate to

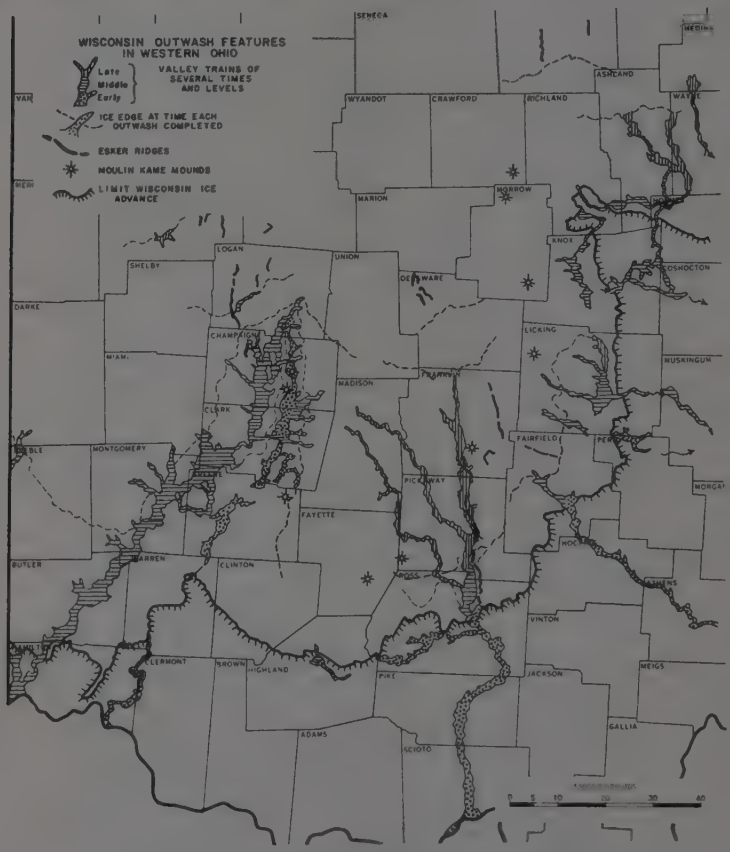


FIGURE 27. Wisconsin outwash features in western Ohio.

entirely different, earlier glaciations.) There are three different lower levels with different kinds of pebbles and different soil cover in Licking, Hocking, and Scioto Valleys (Kempton and Goldthwait, 1959). Longitudinal profiles up and down the valleys depict each level beginning at a different place; yet, each one emanates from a group of ice-contact kames and underdrained kettle holes in end moraine (fig. 31). Clearly the ice edge was wasting away at a different position when each valley train was completed (fig. 27). The higher the terrace level above to-

FIGURE 28. Head of outwash plain at the edge of North Ice Cap, Nunatarssuaq, Greenland. Floods of meltwater build up the gravel plain (lower left) as they did once in each Ohio valley.

FIGURE 29. Floods of silty gray meltwater from Adams Glacier in southeast Alaska, spreading over its outwash plain on a warm summer day.

FIGURE 30. Terrace cut out of glacial valley train along the Mad River Valley just east of Dayton, Ohio. This is composed of sorted sand and gravel beds.

FIGURE 31. Kettle hole collapsing where a modern outwash plain is being built from Hugh Miller Glacier, Alaska. As buried ice melts, out pits form in the sandy gravel.

FIGURE 32. Several glacial tills, some rich in clay and some stoney, are piled one on the other and exposed in this railroad cut south of West Liberty, Ohio.

FIGURE 33. Rolling high ground called end moraine. These form belts across the state. This one is in Greene County, Ohio.

day's river, the farther south and earlier the ice edge was when it formed. From the glacial map, one can deduce that the bulk of outwash was deployed down the valleys in the early stages of retreat. When the ice edge lay north of Powell and Union City Moraine line, no significant outwash deposits were made even although some land naturally drains south

Periods of halt.—The 23 logs actually dated as annihilated during the last ice advance are generally found toward the bottom of a layer of till, but near the surface. In a few cases like that at Sidney (Forsyth and La Rocque, 1956), there are one or two distinctly different layers of till above the logs; some are more pebbly; some vary in color; all vary in stone count lithology (fig. 32). This suggests a change in direction of ice motion after the early advance, or perhaps a retreat and readvance from a different direction.

Halts are most clearly expressed by the belts of *end moraine* hung like festoons across the glacial map in Ohio (fig. 7). Each one is a semicontinuous belt of ground, ten to 300 ft higher than surrounding glacial deposits, or perhaps just thicker till where it is plastered onto bedrock hills as in Logan County or northeastern Ohio. The surface is rolling or hummocky in contrast to the relative flatness of nearby plains, and it bears greater density of scattered boulders (fig. 33). It is composed of till and many lenses of gravel, but there is usually no favored orientation of pebbles or fabric. Thus, each belt of hummocks appears to be dumped or unloaded from the glacier front while it stood along a particular line. Some of these are continuous enough so they can be traced all across western Ohio; others are broken by sharp hills, wide river valleys, or they just fade out. Here and there it is hard to tell which are time equivalents. Most of the moraines have double parallel high areas with minor creeks traveling the line of the moraine between them. Each major moraine appears to be a composite of deposits along closely spaced successive parallel positions of the ice. Where six completely separate moraines converge northward in Clark County, they become the eight-mi wide Cable Moraine belt, yet generally an irregular ridge within the belt marks the position of a contemporaneous ice edge to match each moraine farther south (fig. 7).

No glacier is known today which is producing an end moraine of the breadth and volume of those in Ohio (two mi wide, average 50 ft high). Only in height have they been equalled by the looped moraines built by some mountain glaciers since 1700. On Barnes Ice Cap, Baffin Island, moraines about one-tenth as wide were observed (Goldthwait, 1951). What do they imply in this modern case? Dirt is brought up on shear planes to the ice surface never more than 200 ft vertically above the ice edge nor a quarter mi back from the edge (fig. 34). Here it melts out from June to August and slides down the trickling wet ice surface. It stacks up three to four ft deep over dead ice at the very edge of the glacier, making a temporary ice-cored moraine (fig. 35). Here and there this buried ice melts from below where water opens a hole, where streams cut, or where an ice tube collapses (fig. 36). The covering dirt slips and slides, first one way and then another, until it is all superimposed in heaps on earlier glacial deposits beneath. It ends up dumped as a series of hummocks along the ice edge. If the ice edge is reactivated, it pushes into these hummocks and may repeat over and over, adding to the thickness and width of the accumulated mass (fig. 37). From the sparcely disseminated dirt in this glacier ice (0.3 to 3.0 percent) and sample motion measurements, it has been estimated that the smallest of these moraines takes a century to accumulate.

Each Ohio moraine has easily ten times this bulk, and yet C^{14} dates show that we have nothing like this 1,000 yr to attribute to each belt of moraine. Thus, either ice over Ohio was dirtier than today's example, or the dirt zone was deeper than 200 ft, or the surface ice motion was greater than half a foot per day. Or possibly some moraines were pushed up rapidly. If all three were double, then each Ohio moraine might have been accumulated in a century or two.

Duration of retreat.—The youngest C^{14} samples buried in the outermost Cuba-Hartwell Moraine are 16,560± 230 (Y–450) yr and 17,980± 400 (W 331) yr old. Next youngest are lacustrine and swamp deposits on top of the Wabash Moraine way up northwestern Ohio, these postglacial burials are 14,300± 450 yr old (W-198). If we believe that the ice left the terminal area generally 17,000 yr ago, then we have only about 2,700 yr to remove the ice from over most of Ohio, including the formation of eight moraines to the Wabash Moraine line. Actually, if we assume half of the time of deglaciation was absorbed by halts when the ice edge built moraines, the retreat moved at averages near 300 ft per year, and at least 150 yr was spent by the ice edge at each moraine.

FIGURE 34. Melting ice slope at the south margin of Barnes Ice Cap, Baffin Island. Dirt is brought up only to the white ice lip by shearing upward from the bottom.
FIGURE 35. Dirt (till) accumulating on the ice at the very edge of the ice cap near Dundas, Greenland. This is ice-cored moraine.
FIGURE 36. Till slipping and sliding down the irregular undermined edge of Barnes Ice Cap, Baffin Island, to form hummocks of end moraine in a belt.
FIGURE 37. End moraine ridge with hummocks deposited several centuries ago by Barnes Ice Cap, Baffin Island.

The history of modern glaciers, as in Glacier Bay, Alaska, where new snow supply has been largely cut off since the end of the last century, indicates a maximum recession of about 1,000 ft per year (Field, 1958). This may be the most realistic rate for recession over Ohio, even though there was no water body to accelerate recession of the ice here. Certainly this rate might apply to the ice disappearing up the Erie Basin when it was filled with glacial lakes.

Readvances or long halts?—One reason for insisting that the end moraine de-

posits represent most of the time of overall retreat is that there is evidence along at least three moraine fronts that a significantly long time was involved, or there was actual reexpansion of the ice. Within historic times in the Alps, Norway, and Iceland (Ahlmann, 1953), glaciers have been notorious for pulsating readvances; so, while continental glaciers must work sluggishly and respond only to long-continued climatic changes, such fluctuations are still to be expected.

The first evidence of long halt is the approximate northward limit of a substantial cover of windblown *loess* on top of Wisconsin drift. This is near the outer edge of Camden Moraine and the Reesville Moraine (dashed line in fig. 38). In several dozen samples of soil, two to five ft deep, selected for its smooth silty character, 20 percent was clay (less than 20 μ) derived largely by soil forming

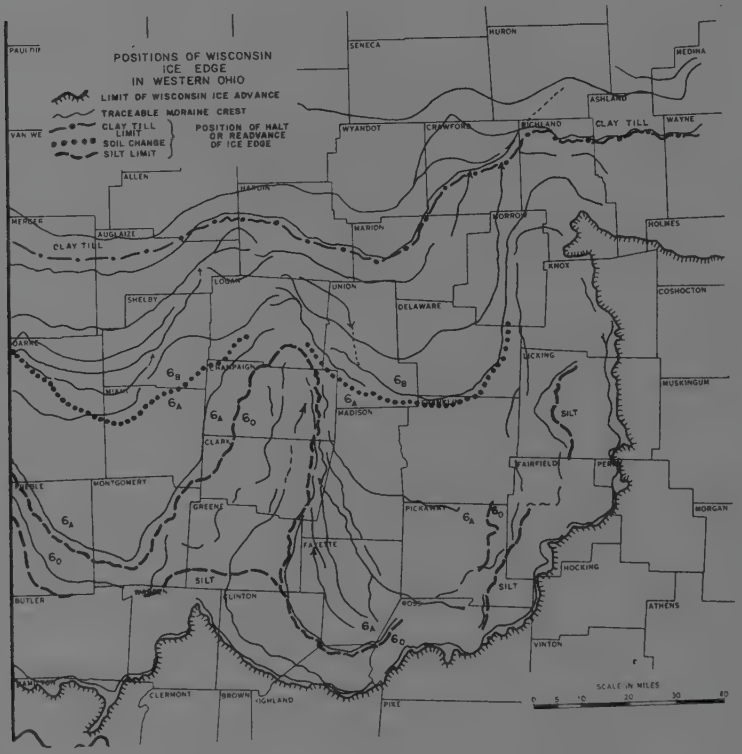


FIGURE 38. Positions of Wisconsin ice edge in western Ohio.

processes, 68 percent was silt (up to 0.05 mm), and only 11 percent was sand, mostly fine. Through wide areas to the south, this covers the gritty-pebbly till, but only thin irregular patches occur north of this "silt" line. Such loess deposition is observed and measured wherever great outwash "valley trains" are built today, as in Greenland or New Zealand. Summer floods spreading over the plains between multitudes of channels leave patches of silt. The silt is picked up and dusted over the leeward countryside by the next gusty frontal wind (fig. 39).

The predominance of minerals, quartz, felspar, and calcite, in Ohio silts is like that in Ohio outwash; so, there is probably an association.

This silt limit is near, but not identical with a change in soils type temporarily designated "Miami 6O" vs. "Miami 6A." Actually, the "6O–6A" line is based on other characteristics such as the greater depth, yellow-red color, and the marked structure in the 6O soils. However, the two limits (silt and soil) are fairly close

FIGURE 39. Clouds of silt-size dust (loess) being blown up by fresh frontal winds off of an outwash plain in Tasman Valley, New Zealand. The silts were deposited by recent floods of glacial meltwater.

FIGURE 40. Ice cliff of Barnes Ice Cap, Baffin Island, advancing into a small ice-dammed lake much as happened many places in northern Ohio.

FIGURE 41. Buried forest stump which grew on the clay beds of former glacial lakes at Castalia, Ohio. This one is 8,500 yr old, and was buried by marl.

except in the interlobate area from Greene County north to Logan County. One might argue that there was no dust available in this interlobate area; yet, there was more glacial outwash in Mad River Valley than in the silty areas of Warren, Clinton, and Highland Counties. The Mad River valley train (fig. 27) leads back nearly to the Farmersville Moraine on the west, and to the Reesville line traced into Cable Moraine on the east. This shows that these two were indeed simultaneous ice edges. Lack of silt cover here is a dilemma but the long halt signified by some two ft of loess to the south suggests one or two long halts.

A second soils change occurs in the vicinity of Powell and Union City Moraines (dotted line in fig. 38). Schafer is finding by a study in progress a subtle change from silty till with sticky brown clay subsoil, and topsoil over ten in. deep (Miami catena) northward to a clay till with shallow topsoil, poorer structure, darker B zone, and lower calcium carbonate (Morley catena). Wenner (thesis in press) has shown that clay content in the parent till increases from about 21 percent to about 33 percent in passing north over this line. Since climate, weathering, and biological activity are identical, the change must relate to the difference in original composition, but this difference reflects new source materials, new directions of ice motion, and therefore probably some readvance. It coincides in position with one of the most prominent end moraine systems in Ohio, and with the last of the valley train systems in Scioto lobe.

The third significant line is either the Wabash Moraine or some line just north of it (dash-dot line in fig. 38). The Wabash Moraine itself cuts directly across earlier moraines, overriding the Powell, Broadway, and St. Johns Moraines in Crawford County. It is much more bouldery than areas to the south, and Gregory (1956) found that soluble carbonates increase from a few percent to over 17 percent in this moraine. Another increase in clay content in till was detected at the south edge of Huron County (Campbell, 1955). Pedologists like Holowaychuk recognize gradual increase of clay northward in the Miami lobe, most markedly between the Wabash and Defiance Moraines. This is attributable to lake floor clays and silts picked up by a readvancing ice (fig. 40). Now we are beginning to find these buried lake floor sediments themselves beneath the uppermost till sheet in Huron County (Campbell, 1955), and Seneca County (Coash, personal communication). Very clearly the ice retreated far into the Erie Basin in what Dreimanis (1958) calls the Erie Interstadial. A lake was trapped in the area between the ice and the Defiance Moraine, and then the ice readvanced nearly to the Wabash Moraine. There is some likelihood that Defiance Moraine is principally an earlier (Iowan?) moraine overriden at this time. Since the oldest logs found buried in late glacial sediments on top of the Wabash Moraine are 14,300 ± 450 yr (W-198) old, it looks as though this readvance culminated at least 14,500 yr ago.

To the west this is the time equivalent of the Cary substage according to one recent estimate (table 2, Ruhe, Rubin, and Scholtes, 1957). In northeastern Ohio this connects to the "late Cary" readvance demonstrated so neatly by a clay till (30 to 50 percent clay) lying over a silty-clay till (20 to 30 percent clay, Shepps, 1953). North of Lake Erie, Dreimanis (1958) has shown the same clay-rich till layer over a silty till, which was actually brought by ice moving northwestward out of the Erie Basin. With such localized radial movement, he and Holmes (1952) suggest a late center of motion right over the Ontario Basin. This is good reason to think that even the Erie Basin was still a local ice-forming center and together with Ontario Lake Basin, it developed the final push of ice over Ohio 14,500 yr ago.

Aftermaths of Glaciation

Aftermaths of glaciation.—By 13,000 yr ago (W-33, Y-240, S-25), several glacial lake levels had existed in the Erie Basin. Niagara outlet was well blocked

by ice, and water standing 230 ft deeper than present Lake Erie first spilled into the Wabash River at Fort Wayne (the Maumee stage). Oscillations produced several levels well worked out by Carney (1909, 1910, 1913). During the short, slowly-dropping level called Lake Akona, the water body extended north to the thumb of Michigan as ice retreated, and it drained by some lower outlet. This long warm period gave trees a chance to come in right down to the lakeshore for, when the lake rose to Whittlesey stage by resurgence of ice (Port Huron Moraine, Michigan), the rising waters drowned the forests and buried the trees under Lake Whittlesey shore sands. This is the earliest firm glacial lake dating.

It is notable that even while ice was as near as northern Lake Erie (Port Huron Moraine), spruce trees grew next to early Lake Whittlesey. Bogs studied by Sears (1930) in northern Ohio show that the accumulation started first with dominance of spruce and some fir pollen. Possibly during the retreat from the Wabash Moraine to northern Lake Arkona between 14,300 and 13,000 yr ago, there was a period of treeless plains, for Lake Maumee has produced no logs. This was a narrow barren belt, if it existed, for trees grew on Wabash Moraine at the start. Thus, rapidly did spread the groups of spruce trees and with them moved the forest-loving mastodon and giant beaver. These populated the country widely for they are associated with the forest in bogs at Columbus and West Jefferson (Thomas et al., 1952). One is dated near 11,480 yr ago (Y–526), which is Two Creeks interstadial time farther west, and the other is 9,600 yr ago which is the end of Valders time.

In another thousand years, however (8,500 yr ago), warm climate had come to Ohio, for Castalia Bog (fig. 41) at this time preserved fragments of oak, elm, poplar, ash, maple (Burns, 1958). Deer became plentiful (Campbell, 1955), but the mastodon was fighting a losing battle. Mean annual temperatures in the 50's (°F) were upon us. Water level dropped to near the present Lake Erie level and the ice had faded rapidly into eastern Canada (Hough, 1958). The ice age was gone from Ohio.

REFERENCES CITED

Ahlmann, H. W. and **S. Thorarinsson.** 1939. Vatnajokull, scientific results of the Swedish-Icelandic investigations 1936–37–38, Chapter 6. The Accumulation. Geografiska Analer 1: 41–66.

———. 1940. Chapter 10. The relative influence of precipitation and temperature on glacier regime. Geografiska Analer 3–4: 188–205.

Ahlmann, H. W. 1953. Glacier variations and climatic fluctuations. American Geogr. Soc., Bowman Memorial Lectures, Series 3.

American Geographical Society. 1958. Antarctica. (map) 1: 6,000,000 prepared for National Acad. Sci., U. S. National Committee, I.G.Y.

Antevs, E. 1932. Alpine zone of Mt. Washington Range. Auburn, Me.: 118 pp.

Apfel, E. T. 1952. Antarctica drainage pattern (abst.). Bull. Geol. Soc. Amer. 63: 1232.

Braun, E. L. 1928. Glacial and post-glacial migrations indicated by relic colonies of southern Ohio. Ecology 9: 284–302.

Burns, G. W. 1958. Wisconsin age forests in western Ohio, II. Vegetation and burial conditions. Ohio Jour. Sci. 58: 220–230.

Campbell, L. J. 1955. The late glacial and lacustrine deposits of Erie and Huron counties, Ohio. The Ohio State University, Ph.D. dissertation.

Carney, F. 1909. The raised beaches of the Berea, Cleveland, and Euclid sheets, Ohio. Denison Univ. Science Lab. Bull. 14: 262–287.

———. 1910. The abandoned shore lines of the Oberlin quadrangle, Ohio. Denison Univ. Science Lab. Bull. 16: 101–117.

———. 1913. Some proglacial lake shorelines of the Bellevue quadrangle, Ohio. Denison Univ. Science Lab. Bull. 16: 231–246.

Chamberlin, T. C. 1882. Terminal moraine of the second glacial epoch. U. S. Geol. Sur. Ann. Rpt. 1882: 291–402.

Deevey, E. S., Jr. 1949. Biogeography of the Pleistocene, Part 1: Europe and North America. Bull. Geol. Soc. Amer. 60: 1315–1416.

Denny, C. S. 1956. Surficial geology and geomorphology of Potter County, Pennsylvania. Geol. Surv. Prof. Paper 288.

Diamond, M. 1958. Air temperature and precipitation on the Greenland Ice Cap. U. S. Army Engineers Snow, Ice, and Permafrost Research Establishment, Research Rpt. 43.
Dreimanis, A. 1958. Wisconsin stratigraphy at Port Talbot on the north shore of Lake Erie, Ontario. Ohio Jour. Sci. 58: 65–84.
——— and **J. Terasmae.** 1958. Stratigraphy of Wisconsin glacial deposits of Toronto area, Ontario. Proc. Geol. Assoc. Can. 10: 119–135.
Field, W. O., and others, 1958. Geographic study of mountain glaciation in the northern hemisphere. American Geog. Soc. Rpt. to U. S. Army Quartermaster.
Forsyth, Jane L. and **A. La Rocque.** 1956. Age of the buried soil at Sidney, Ohio. (abst.) Bull. Geol. Soc. Amer. 67: 1696.
Goldthwait, R. P. 1940. Geology of the Presidential Range. New Hampshire Acad. Sci. Bull. 1: 43 pp.
———. 1951. Development of end moraines in east-central Baffin Island. Jour. Geol. 59: 567–577.
———. 1957. Study of ice cliff in Nunatarssuaq, Greenland. The Ohio State University Research Foundation, Project 636, Rpt. 17.
———. 1958. Wisconsin age forests in western Ohio, I. Age and glacial events. Ohio Jour. Sci. 58: 209–219.
Gregory, J. F. 1956. The Pleistocene geology of Crawford County, Ohio. The Ohio State University, Thesis for M.Sc.
Harrison, P. W. 1957. A clay-till fabric: its character and origin. Jour. Geol. 65: 275–307.
Holmes, C. D. 1941. Till fabric. Bull. Geol. Soc. America. 52: 1299–1354.
———. 1952. Drift dispersion in west-central New York. Bull. Geol. Soc. Amer. 63: 993–1010.
Holmes, G. W. 1955. Project Mint Julep, investigation of smooth ice areas of the Greenland Ice Cap, 1953, Part II. Air Univ., Arctic, Desert, Tropic Information Center. 100 pp.
Horberg, L. 1955. Radiocarbon dates and Pleistocene chronological problems in the Mississippi Valley region. Jour. Geol. 63: 278–286.
Kempton, J. P. and **R. P. Goldthwait.** 1959. Glacial outwash terraces of the Hocking and Scioto River valleys, Ohio. Ohio Jour. Sci. 59: 133–151.
Hough, J. L. 1958. Geology of the Great Lakes. Univ. Illinois Press: 90–129.
Kruger, F. C. 1937. A sedimentary and petrographic study of certain glacial drifts of Minnesota. Amer. Jour. Sci. 34: 345–363.
La Rocque, A. and **Jane L. Forsyth.** 1957. Pleistocene faunules of the Sidney cut, Shelby County, Ohio. Ohio Jour. Sci. 57: 81–89.
Leonard, A. B. 1953. Molluscan faunules in Wisconsinian loess at Cleveland, Ohio. Amer. Jour. Sci. 251: 369–376.
Leverett, F. 1902. Glacial formations and drainage features of the Erie and Ohio basins. U. S. Geol. Survey, Monograph 41.
Martin, P. S. 1959. How many logs make a forest? Ohio Jour. Sci. 59: 221–222.
Rausch, D. O. 1958. Ice Tunnel, Tuto area, Greenland. U. S. Army Engineers, Snow, Ice, and Permafrost Research Establishment, Tech. Rpt. 44.
Ruhe, R. V., M. Rubin, and **W. H. Scholtes.** 1957. Pleistocene radiocarbon chronology in Iowa. Amer. Jour. Sci. 255: 671–689.
Schytt, V. 1955. Glaciological investigations in the Thule Ramp area. U. S. Army Engineers, Snow, Ice, and Permafrost Research Establishment, Rpt. 28.
Sears, P. B. 1930. A record of post-glacial climate in northern Ohio. Ohio Jour. Sci. 30: 205–217.
———. 1941. Post-glacial vegetation in the Erie-Ohio area. Ohio Jour. Sci. 41: 225–234.
Sharp, R. P. 1951. Accumulation and ablation on the Seward-Malaspina Glacier system, Canada-Alaska. Bull. Geol. Soc. Amer. 62: 725–744.
———. 1954. Glacier flow: a review. Bull. Geol. Soc. Amer. 65: 821–838.
Shepps, V. C. 1953. Correlation of the tills of northeastern Ohio by size analysis. Jour. Sediment. Petrol. 23: 34–48.
Thomas, E. S. 1951. Distribution of Ohio animals. Ohio Jour. Sci. 51: 153–167.
Thomas, E. S. et al. 1952. The Orleton Farms mastodon. Ohio Jour. Sci. 52: 1–28.
Thorarinsson, S. 1943. Oscillations of the Iceland glaciers in the last 250 years. Geog. Analer. 25: 54 pp.
VerSteeg, K. 1933. The thickness of the glacial deposits in Ohio. Science. 78: 459.
Victor, P. E. 1953. Campagne au Groenland. Expeditions Polaires Francaise, Publ. Prelim. 16.
White, G. W. 1953. Sangamon soil and early Wisconsin loesses at Cleveland, Ohio. Amer. Jour. Sci. 251: 362–368.
White, S. E. 1956. Glaciological studies of two outlet glaciers, northwest Greenland, 1953. Medd. om Grønland. 137: 31.

RECORDS OF THE ALLEGHENY BROOK LAMPREY *ICHTHYOMYZON GREELEYI* HUBBS AND TRAUTMAN, FROM WEST VIRGINIA, WITH COMMENTS ON ITS OCCURRENCE WITH *LAMPETRA AEPTYPERA* (ABBOTT)

FRANK J. SCHWARTZ†

Chesapeake Biological Laboratory, Solomons, Maryland

The upper Ohio River system of New York, Pennsylvania, and Ohio has generally been cited as the range of the Allegheny Brook Lamprey *Ichthyomyzon greeleyi* Hubbs and Trautman (Blair et al. 1957; Hubbs and Trautman, 1937; Raney, 1939a; Trautman, 1957). Recently, Clay and Lachner (1955) reported the existence of *Ichthyomyzon greeleyi* in Russel Creek, a tributary of the Green

TABLE 1*

Measurements of male and female Ichthyomyzon greeleyi *in thousandths of the total length from two localities within the Ohio River drainage, West Virginia*

Locality and Specimen No.	Sex	Total length	Tail length	Body depth	Eye length	Snout length	Disk length	Gill length overall
Meathouse Fork								
USNM 170972	♂	161.5	242	79	14	69	53	109
Little Kanawha River								
USNM 171992								
Ammocoete	—	125.3	274	65	—	—	—	113
1	♂	130.0	292	81	14	83	63	88
2	♂	129.7	292	83	12	89	62	110
3	♂	129.6	299	81	13	89	56	99
4	♂	127.5	308	72	13	89	63	114
5	♂	126.0	286	81	15	75	55	99
6	♂	123.9	281	76	13	78	61	98
7	♂	120.5	283	84	16	84	63	107
8	♂	118.8	287	80	12	87	63	98
9	♂	116.5	303	70	13	82	55	99
10	♂	114.1	304	84	11	82	53	104
11	♂	113.8	294	69	13	80	55	110
12	♂	113.5	273	65	12	84	58	115
13	♂	112.7	289	83	17	89	66	11
14	♂	111.6	283	73	13	84	58	101
15	♂	109.2	302	75	16	87	60	105
16	♂	108.7	290	82	17	78	60	107
17	♂	106.0	269	74	14	89	61	118
Averages		118.4	290	77	14	84	60	105
18	♀	129.6	287	75	11	80	52	110
19	♀	127.9	270	70	15	81	52	108
20	♀	124.6	258	70	10	76	51	106
21	♀	121.8	278	71	11	90	52	100
22	♀	121.0	285	68	12	74	59	104
23	♀	117.8	267	69	13	70	54	107
24	♀	114.9	280	70	14	79	55	103
25	♀	114.3	262	70	14	68	52	103
26	♀	109.6	283	67	14	75	57	107
27	♀	109.2	268	82	15	75	60	115
Averages		119.1	272	71	13	77	54	106
Grand Averages		118.9	283	75	13	81	58	106

*All values, except total length, are rounded off.

†Contribution No. 120, Maryland Department of Research and Education, Solomons, Maryland.

River, Adair County, Kentucky. The later record of 4 specimens extended the known range of this lamprey some 400 mi southwest from that of the upper Ohio River to the Green River drainage of the lower Ohio River system.

A male lamprey, *Ichthyomyzon greeleyi*, 161.5 mm long, USNM 170972, was captured on March 20, 1957, in Meathouse Fork of Middle Island Creek, one and one-half mi downstream from New Milton, Doodridge County, West Virginia.

TABLE 2

Myomere and tooth counts for male and female Ichthyomyzon greeleyi from *two localities within the Ohio River drainage, West Virginia*

Locality and Specimen No.	Sex	Myomeres	Superorals	Inferorals	Circumorals	Anterior row	Lateral row	Biscuspid circumorals
Meathouse Fork								
USNM 170972	♂	58	3	8	21	4	7	10
Little Kanawha River								
USNM 171992								
Ammocoete	—	56	—	—	—	—	—	—
1	♂	58	3	10	21	4	7	9
2	♂	59	2	8	20	4	7	10
3	♂	58	2	7	21	4	7	9
4	♂	56	3	9	22	3	7	8
5	♂	57	3	6	20	4	6	8
6	♂	58	3	9	21	3	7	9
7	♂	60	3	9	21	4	7	8
8	♂	60	3	9	23	3	6	8
9	♂	55	3	9	22	4	7	8
10	♂	59	2	9	20	3	7	8
11	♂	57	2	6	18	4	6	7
12	♂	57	3	8	20	3	7	8
13	♂	56	3	8	22	4	7	8
14	♂	59	3	8	20	3	6	8
15	♂	60	3	10	20	4	7	8
16	♂	58	2	6	20	4	7	8
17	♂	56	2	8	21	3	7	10
Averages		57.8	2.6	8.2	20.1	3.6	6.7	8.4
18	♀	60	2	8	20	3	6	8
19	♀	60	2	8	22	3	6	8
20	♀	58	2	10	20	4	5	8
21	♀	60	3	9	20	4	7	8
22	♀	59	3	9	22	3	7	9
23	♀	58	3	8	21	4	7	10
24	♀	59	3	9	22	3	6	10
25	♀	58	3	8	20	3	7	8
26	♀	57	3	8	21	3	6	8
27	♀	58	3	8	22	4	7	8
Averages		58.7	2.7	8.8	21.0	3.4	6.4	8.5
Grand Averages		58.1	2.7	8.3	20.8	3.5	6.6	8.4

In addition, the author collected one ammocoete and 27 spawning *greeleyi*, USNM 171992, on May 16, 1958, from the Little Kanawha River at and for a distance 0.3 mi south of Falls Mills, Braxton County, West Virginia. The capture of these specimens extends the range some 300 mi northeast of Russel Creek, Kentucky, (Clay and Lachner 1955) and supports the distribution rounded out by Trautman (1957, Map 4) as extending along western West Virginia north to Pennsylvania and south to Kentucky.

The single specimen from Meathouse Fork was difficult to identify because of its large body size, certain meristic counts and body proportions intermediate between *I. greeleyi* and the parasitic form *I. bdellium* (tables 3 and 4). Counts and measurements, expressed in thousandths of the total length, of the 28 specimens captured in the Little Kanawha River (tables 1 and 2) readily fell (tables

TABLE 3

Summary comparison of measurements of Ichthyomyzon greeleyi. *Range of variation and averages with those of* Ichthyomyzon bdellium†

	Locality	No. of specimens	Total length (in mm)	Tail length§	Body depth§	Eye length§	Snout length§	Disk length§	Gill openings length overall§
Ichthyomyzon greeleyi	Pennsylvania (Total)	109	128.0 105–161	297 245–325	76 59–90	13 10–16	73 51–88	53 43–65	98 88–110
	Kentucky	4	122	———	———	———	———	47.6 41–52	———
	West Virginia Meathouse Fork	1	161.5	242	79	14	69	53	109
	Little Kanawha River	28	118.9 106–130	283 258–308	75 65–84	13* 10–17	81* 68–90	58* 51–66	106 88–118
Ichthyomyzon bdellium	Illinois to N. Carolina	27	189 124–259	274 214–311	73 62–92	11 6–15	86 29–91	69 35–77	89 84–107

†Information on *Ichthyomyzon greeleyi* from Hubbs & Trautman, 1937 and Clay and Lachner, 1955 and *I. bdellium* from Hubbs & Trautman, 1937.

§Measurements in thousandths of total length.

*27 specimens.

TABLE 4

Summary comparison of myomere and tooth counts of Ichthyomyzon greeleyi; *range of variation and averages with those of* Ichthyomyzon bdellium†

	Locality	No. of specimens	Myomeres	Superorals	Infraorals	Circumorals	Anterior row	Lateral row	Bicuspid circumorals
I. greeleyi	Pennsylvania (Total)	109	57.9 55–61	2.8 2–4	9.4 7–12	21.5 19–24	4.1 3–5	7.2 5–9	8.4 7–11
	Kentucky	4	57.5 56–58	3 ——	9.3 7–10	——	——	——	7.8 7–8
	West Virginia Meathouse Fork	1	58	3	8	21	4	7	10
	Little Kanawha R.	27	58.1* 56–60	2.7 2–3	8.3 6–10	20.8 18–23	3.5 3–4	6.6 5–7	8.4 7–10
I. bdellium	Illinois to N. C.	27	56.9 53–62	2.6 2–3	8.4 7–10	20.8 19–21	4.3 4–5	8.3 7–10	7.8 5–10

†Information on *Ichthyomyzon greeleyi* from Hubbs & Trautman, 1937 and Clay and Lachner, 1955 and *I. bdellium* from Hubbs & Trautman, 1937.

*28 specimens.

3 and 4) within the known variation of *greeleyi* (Hubbs and Trautman, 1937; Clay and Lachner 1944). Males generally had longer tails, snouts, oral disks, shorter gill lengths and wider bodies than females.

I. greeleyi was taken at both localities in streams with gentle gradients of approximately 50 to 75 ft in width. Where riffles occur the bottoms are composed of boulders, gravel and sand while interspaced pools have bottoms of shifting sand. Riffle boulders ranged in size from 6 to 24 in. in diameter and often 12 in. in thickness.

Raney (1939b) observed and breeding of *greeleyi* in the Little Neshannock Creek, Pennsylvania, between May 19 and 26. He noted also that spawning was most intense at 3 PM and that it occurred on or at the crest of riffles. Trautman (1957) comments that spawning occurs about May 10 and 11. The spawning period of *greeleyi* in the Little Kanawha River occurred within the period noted above. Spawning was most intense between 2 and 5 PM, but did not occur on or at the crest of riffles; instead the middle and lower portions of the riffles were utilized.

An interesting point of association exists in that *Ichthyomyzon greeleyi* and *Lampetra aepyptera* occur in the same stream systems. Both species were collected together in Meathouse Fork, whereas in the Little Kanawha, these two species occupy different parts of the same stream system. Hubbs and Trautman (1936: 46) speculated that if these two species should be found in the same stream system, they would avoid each other, as both adults and ammocoetes of *aepyptera* would inhabit smaller brooks while *greeleyi* would occur in the larger creeks and smaller rivers. This situation was observed in the Little Kanawha River where *aepyptera* is found in the smaller tributaries such as Sand Fork, one-fourth mi north of Sand Fork, West Virginia, and in the narrower portion of the Little Kanawha River downstream from Falls Mills at Burnsville, West Virginia. The Little Kanawha River, at this point, is peculiar in that its middle section is a constricted, deep-pooled, high banked, slow meandering stream 20 to 50 ft wide, sporadically possessing riffles. Above this area, as the stream flows out of the mountains, it is a fast flowing shallow stream. Below the constricted area, beginning at Grantsville, West Virginia, and for some 50 mi until its junction with the Ohio River at Parkersburg, West Virginia, the meandering river is wide, slow and deep. It is peculiar that *I. greeleyi* occupies the stream system above this constricted area where *L. aepyptera* has been found to occupy the constricted zone of the river. *L. aepyptera* is further isolated from *greeleyi* as it spawns at the crest of riffles and earlier, spawning April 3 to 6, 1958.

ACKNOWLEDGMENTS

Appreciation is extended R. Hawse and P. Zurbuch of the West Virginia Conservation Commission who directed the Meathouse Fork specimen to my attention; Dr. E. A. Lachner, Associate Curator Fishes, U. S. National Museum, for aid with the identification of this specimen and review of the manuscript; Mr. Don Oberacker, University of Maryland, for aid in seining.

LITERATURE CITED

Blair, W. F., A. P. Blair, P. Brodkorb, F. R. Cagle and **G. A. Moore.** 1957. Vertebrates of the United States. McGraw Hill Co., N. Y. viii+819 pp, 416 fig.

Clay, W. M. and **E. A. Lachner.** 1955. Occurrence of the Lamprey *Ichthyomyzon greenleyi* Hubbs and Trautman in Kentucky. Trans. Kent. Acad. Sci. 16: 53–55.

Hubbs, C. L. and **M. B. Trautman.** 1937. A revision of the lamprey genus *Ichthyomyzon*. Misc. Publ. Mus. Zool. Univ., Univ. Michigan. 35: 1–109.

Raney, E. C. 1939a. The distribution of the fishes of the Ohio drainage basin of western Pennsylvania. Cornell Univ. Abstracts of Thesis (1938): 273–277, maps 1–122.

———. 1939b. The breeding habits of *Ichthyomyzon greeleyi* Hubbs and Trautman. Copeia 2: 111–112.

Trautman, M. B. 1957. The Fishes of Ohio, with illustrated keys. Ohio State University Press. xvii+683 pp, 172 maps, 172 figs., 7 plates.

HOW MANY LOGS MAKE A FOREST?†

PAUL S. MARTIN

Geochronology Laboratories, University of Arizona, Tucson

The nature of ice-margin conditions is a durable problem in paleoecology. In a recent contribution Goldthwait (1958) and Burns (1958) provide a valuable stratigraphic account of wood from Wisconsin and post-Wisconsin age deposits in Ohio. From glacial till they report abundant records of spruce logs, less often of larch and white cedar, that indicate relatively short distance of transport by the Wisconsin glacier near its margin. Seventeen radiocarbon dates of this wood from 27,500 to 16,560 years ago bracket the last Wisconsin glacial maximum. Goldthwait (p. 213) concludes that, locally, the ice sheet pushed into extensive patches of living forest climatologically akin to those of north central Ontario. Burns (p. 223) interprets this as a relatively narrow band of coniferous forest, mainly spruce. To support the concept of a narrow coniferous zone, he cites Braun's postulate of deciduous forest fifty miles south of the drift border (Braun, 1951).

The query raised by my title now emerges. Are abundant broken logs embedded in till prima-facie evidence that ice moved through and buried a closed canopy *forest?* Or was it an open woodland of a savanna type, with dense tree growth only along drainage systems? Or was it a wooded-tundra (lyesotundra) resembling the subarctic treeline?

To the paleoecologist and paleoclimatologist the distinction is crucial. If a narrow zone of periglacial boreal forest bordered the ice sheet, it is reasonable to assume that a temperate climate and deciduous forest biota lay slightly beyond. Braun's concept of an ice margin refugium for such plants would be supported. If, however, the ice margin were occupied by *woodland* or wooded tundra, both boreal and deciduous forest zones would have suffered a greater displacement (cf. Martin, 1958).

To consider a hypothetical illustration, an ice sheet advancing southward into northern Quebec at 58° north latitude would encounter pole-sized spruce and larch in dense groves along rivers. This is the northern limit of tree growth in eastern Canada (fig. 1). Farther south, in the boreal woodland or taiga, ". . . tall and well-developed spruce . . . stand several yards apart in a sea of *Cladonia*" (Hare 1950: 624). Here an ice sheet might bury the following: white and black spruce at a density of 400 trees per acre, white spruce on the best sites up to 59 feet tall, 28 inches in diameter, and over 158 years in age. In such terms Hustich (1954) described "forests" at Knob Lake, 55° north. By comparison with closed-canopy boreal forests of southern Canada, this is slow growth and low stature. By comparison with the growth of trees at their limit in northern Quebec, it is luxuriant. In each case the ice sheet could have covered, locally at least, abundant logs. What type of trees were buried in Ohio?

Although distortion or compression may have altered the ring width, it is of interest to compare Hustich's Knob Lake data with those of the fossil logs studied by Burns. With one exception, the annual ring growth measurements of 1.4 mm or less on Wisconsin-age trees in Ohio (Burns, p. 225–226) are matched and frequently exceeded by ring measurements of black and white spruce from good sites in the Knob Lake woodland. The single exception is log 272 from Anderson Run, in which Burns recorded a maximum annual ring increment of over 4.2 mm, twice the maximum Hustich reported at Knob Lake. Perhaps it is not a coincidence that the Anderson Run locality also included wood of white cedar (*Thuja*).

†Contribution No. 17 of the Program in Geochronology, University of Arizona.

THE OHIO JOURNAL OF SCIENCE 59(4): 221, July, 1959.

Although *Thuja* reaches the subarctic lowlands of James Bay (Hustich, 1957, map 8), it is more commonly found within true boreal forest to the south. On these grounds the Anderson Run locality might be considered representative of *boreal forest* rather than *boreal woodland*.

On the other hand the description of wood from other Ohio sites, with diameters and ring growth features equivalent to those recorded at Knob Lake, does not invite the strict generalization of forest. To me it indicates that the advancing Wisconsin sheet swept through a zone of scattered trees, relatively dense along drainage ways, but perhaps enclosing patches of tundra on hilltops (fig. 1). Farther south closed canopy coniferous, rather than deciduous forest, occupied the Appalachian Plateaus in southern Ohio and Kentucky.

FIGURE 1. Lyesotundra at the subarctic tree line, Fort Chimo, Quebec, 58° N. Lat. Lichen-heath tundra occupies the foreground and horizon, while a dense wood of larch and black spruce grows along drainage only. Did Ohio glacial forests resemble this?

As stressed by Hare (1950), Hustich (1949), and Rousseau (1952), there are three distinct vegetation zones, wooded tundra, boreal woodland, and boreal forest, south of the tundra in eastern Canada. Spruce (*Picea*) is common in each. By careful comparison of growth features, as Burns' data allow, it may be possible to relate fossil logs to a narrow segment of the modern vegetation gradient. While we lack sufficient information on subarctic tree growth to attempt a detailed comparison, it is notable that rings of most fossil Ohio logs do not exceed in width those of trees from the boreal woodland.

REFERENCES

Braun, E. L. 1951. Plant distribution in relation to the glacial boundary. Ohio Jour. Sci. 51: 139–146.

Burns, G. W. 1958. Wisconsin age forests in western Ohio II. Vegetation and burial conditions. Ohio Jour. Sci. 58: 220–230.

Goldthwait, R. P. 1958. Wisconsin age forests in western Ohio I. Age and glacial events. Ohio Jour. Sci. 58: 209–219.

Hare, F. K. 1950. Climate and zonal divisions of the boreal forest formation in eastern Canada. Geograph. Rev. 40: 615–635.

Hustich, I. 1949. On the forest geography of the Labrador Peninsula. Acta Geograph. 10: 1–63.

———. 1954. On forests and tree growth in the Knob Lake Area, Quebec-Labrador Peninsula. Acta Geograph. 13: 1–60.

———. 1957. On the phytogeography of the subarctic Hudson Bay lowland. Acta Geograph. 16: 1–48.

Martin, P. S. 1958. Pleistocene ecology and biogeography of North America; in Zoogeography, AAAS Symposium Volume, pp. 375–420.

Rousseau, J. 1952. Les zones biologiques de la Péninsule Québec-Labrador et l'hémiarctique. Can. Jour. Bot. 30: 436–474.

OXIDATIVE METABOLISM OF WASHED RESIDUES OF RAT SMALL INTESTINAL EPITHELIUM†

JESSIE FISCHER MOINUDDIN, MARIA LEE KOH AND JUDITH FEIL CUSHING

Department of Home Economics, The Ohio Agricultural Experiment Station, and the Institute of Nutrition and Food Technology, The Ohio State University, Columbus 10

Few studies have been made of the energy-producing oxidation reactions catalyzed by small intestinal epithelium. Studies made with slices have shown that this tissue exhibits a high level of oxidative activity and a high rate of aerobic glycolysis (Dickens and Weil-Malherbe, 1941). Homogenates of the epithelium catalyze the oxidation of α-ketoglutarate (Moinuddin and Cushing, 1957). Isocitric dehydrogenase (Adler et al., 1939) and aconitase (Johnson, 1939) are present in intestinal extracts, and respiration of intestine was stimulated markedly by glucose and slightly by glutamic acid (Rose and Archdeacon, 1953), but the distribution of these activities in various layers of the gut was not described. Intestinal xanthine oxidase is thought to be localized in the mucosa (Westerfeld and Richert, 1954). The accumulation of citrate in the small intestine after the injection of fluoroacetate into animals indicated that the citric acid cycle probably is a major oxidative pathway in the small gut as in other animal organs (Buffa and Peters, 1949) but to what extent this is true for the different gut layers was not determined. Thus, there appears to be little known regarding specific oxidations in gut epithelium by itself. In view of the importance of oxidation reactions in the absorption of certain sugars (Darlington and Quastel, 1953; Ponz and Lluch, 1955) and in other functions of this tissue, it appeared worthwhile to study the oxidative metabolism in some detail.

It will be shown herein that washed residues prepared from gut epithelium catalyze (a) the oxidation of substrates of the citric acid cycle and of various other substances, and (b) the formation of citrate from oxalacetate or from pyruvate plus oxalacetate. Requirements for cofactor fortification of the preparations are partially delineated.

EXPERIMENTAL METHODS

Mature, male Sprague-Dawley rats were allowed access to feed (Rockland Rat Pellets, complete) until they were killed, since previous work had shown that the oxidation of added α-ketoglutarate by whole homogenates of small gut epithelium was markedly decreased in fasted rats (Moinuddin and Cushing, 1957). Homogenates of essentially the entire epithelium were prepared in ice-cold 0.25 M mannitol solution by the method of Hele (1953) with modifications (Moinuddin and Cushing, 1957). After straining out the nonepithelial residues, the homogenates were further briefly homogenized in a Potter-Elvehjem apparatus with a tight-fitting, motor-driven pestle having teeth; some columnar cells remained unbroken even after this treatment. Washed residues were then prepared by centrifuging the homogenate in Lusteroid tubes at 6900 x *g* (calculated to the ends of the tubes) for 10 min at 0 to 4° C. The supernatant fluid was poured off, carrying with it some white, solid material which floated on the surface. The residue consisted of three layers: (a) an upper, thin, white layer; (b) the main, bulky, viscous, tannish layer; and (c) at the bottom, a very small, tan disk which usually contained some red blood cells. A volume of mannitol solution equal to one-half the volume of the original strained homogenate was added to the residue and the tube was swirled, thus dislodging the upper two layers which were then poured off with

†This investigation was supported in part by a grant from the Ohio State University Development Fund. This paper has been approved for publication as journal article no. 50-58 by the Associate Director of the Ohio Agricultural Experiment Station.

and homogenized into the solution. The small tan disk, which adhered to the tube wall, was discarded. The homogenized upper layers were recentrifuged in clean tubes as before. The supernatant fluid was discarded, and the residue was resuspended as before except that the small tan disk frequently adhered to the main pellet rather than to the tube and could not be removed. The final suspensions contained 1.2 mg of nitrogen per milliliter on the average; they usually still contained some recognizable unbroken principal cells of the epithelium.

In the respiration studies, standard Warburg manometric procedures were employed. Each reaction component was added to the flasks in approximately isosmolar solution. Each Warburg flask contained the following standard components (amounts in micromoles): 50 of tris(hydroxymethyl)aminomethane which had been brought to pH 8.0 with hydrochloric acid, 40 of potassium phosophate at pH 8.0, 20 of magnesium chloride, 0.03 of cytochrome *c*, and 6 of adenosine triphosphate (ATP) which had been neutralized with potassium hydroxide. The high pH of the buffer was needed to give the desired pH of the mixtures (after adding the acidic residue) of 7.3 to 7.6, while still keeping the osmolarity and volume of the buffer solution within useful limits. The total volume, allowing for addition of substrates, other cofactors, and 1.0 ml of the washed residue suspension, was made up to 3.0 ml with 0.154 M potassium chloride solution. The substrates were added as potassium salts except for pyruvate, β-hydroxybutyrate, isocitrate and acetoacetate, which were added as sodium salts. The flasks containing the reaction mixtures were chilled to 0° C. before adding chilled solutions of the less stable components and the chilled, freshly-prepared residue preparation. Sodium hydroxide and a fluted filter paper were used in the center well. The gas phase was air, the temperature of the bath 35° C, and the equilibration period 10 min. The comparative results with different substrates are calculated on the basis of the first 10 min after equilibration, since the uptakes with some of the substrates decreased considerably or ceased within 10 to 20 min. Oxidation due to microorganisms is not a problem during this early period in slices (Dickens and Weil-Malherbe, 1941) or homogenates (Moinuddin and Cushing, 1957) of epithelium; probably it is not significant in the residues either since the cold temperatures at which they were prepared do not favor proliferation of most intestinal organisms and since, also, the falling oxidation observed is not characteristic of microbial metabolism.

In all but a few instances, duplicate flasks were run with each substrate and endogenous variation, and the average of closely agreeing duplicates is given.

Citrate was estimated in trichloracetic acid filtrates of some of the reaction mixtures by the method of Natelson et al. (1948), and acetoacetate was estimated in a few filtrates by the method of Barkulis and Lehninger (1951). The nitrogen content of each residue preparation was determined by a micro-Kjeldahl procedure.

Materials were obtained as follows: dipotassium ATP (non-crystalline) and coenzyme A (CoA) (75%) from Pabst Laboratories; cytochrome *c*, CoA (75%), disphosphopyridine nucleotide (DPN) (90% or better,) triphosphopyridine nucleotide (TPN) (96.5%) from Sigma Chemical Co.; oxalacetic acid and *cis*-aconitic acid from H. M. Chemical Co.; L-glutamic acid from Merck & Co.; α-ketoglutaric acid, sodium pyruvate, sodium DL-β-hydroxybutyrate, and trisodium isocitrate (mixture of *dl* and allo forms) from Nutritional Biochemicals Corp. Sodium acetoacetate was synthesized according to Krebs and Eggleston (1945). Other substrates and mannitol usually were Eastman products.

RESULTS AND DISCUSSION

Many experiments established that the standard system used herein usually would support the oxidation of a number of physiologically important compounds by the washed residues (table 1). A few preliminary studies on the standard components were conducted. These showed that when cytochrome *c* was omitted,

the oxidation of citrate in the presence of DPN failed, and the oxidation of succinate was decreased; therefore, cytochrome *c* was included routinely. Results with heart mitochondria in the presence of DPN (Plaut and Plaut, 1952) and certain results with liver mitochondria in the absence of added DPN (Lardy and Wellman, 1952) indicate that the oxidation of citrate may be depressed by adding ATP at about the same level (0.002 M) as used herein. However, oxidation of citrate by our intestinal residues in the presence of DPN was not depressed very much by ATP; and so in view of its usefulness in promoting oxidation of many substrates by certain preparations from other tissues, ATP was used in all experiments. The omission of magnesium from the system was detrimental to the oxidation of many substances, so magnesium was always included. Malonate was found to inhibit the oxidation of succinate.

TABLE 1

Rates of oxidation by washed residues of rat small intestinal epithelium

Substrate*	Oxygen uptake, μl/mg N/hr†			
	All experiments‡		Individual experiments§	
	No DPN added	3 μmole DPN added	No DPN added	3 μmole DPN added
No substrate	27± 4 (24)	51± 4 (32)		
Citrate	13± 7 (4)	98±19 (3)	30	99
			0	64
cis-Aconitate	0± 0 (2)	124±59 (2)	0	65
			0	183
Isocitrate	32± 2 (2)	118±30 (3)	34	128
			31	77
Glutamate	38±14 (5)	90±24 (2)	58	115
			13	66
α-Ketoglutarate	83±24 (9)	104±25 (8)	106	125 n.s.
			245	237 n.s.
			126	137 n.s.
Succinate	343±55 (12)	171±59 (3)	457	266
			362	185
Fumarate	57±19 (7)	80±20 (5)	7	82
			0	52
Malate	58±27 (4)	126±25 (4)	37	168
			7	77
Oxalacetate	52± 5 (2)	45± 2 (2)	47	46 n.s.
Oxalacetate, 10 μmole	81±47 (3)	67±33 (3)		
Pyruvate	96±33 (3)	68±35 (4)	53	41 n.s.
β-Hydroxybutyrate	59± 2 (2)	87±12 (5)	57	76
			60	84
Acetate		23±10 (7)		
Acetoacetate		30± 7 (4)		
Crotonate		15± 2 (2)		
Butyrate		26± 3 (6)		
Octanoate, 18 μmole		15± 5 (4)		

*30 μmole/flask, except where otherwise noted.

†Values for substrates have been appropriately corrected for the uptake with no substrate in each respective experiment, and calculated for the first 10 min after equilibration.

‡Mean ± standard error of the mean (S. E.), for the number of observations given in parentheses. S. E. $= \pm\sqrt{\frac{\Sigma(d^2)}{n(n-1)}}$, where d = the deviation of individual values from the mean, and n = number of observations.

§The effect of DPN is marked not significant (n. s.) in the individual experiments in which there was any overlap of values for flasks with DPN and flasks without DPN. (DPN increased the uptake with no substrate in all 15 experiments in which it was specifically tested; these numerous individual values are not given.)

Effect of DPN. Most of the individual experiments were set up to test the oxidation of several compounds simultaneously under one set of conditions (i.e., either in the presence or absence of DPN). The values obtained in this way with many of the substrates were so variable under either set of conditions (table 1, all experiments) that the effect of adding DPN was specifically tested in a few experiments (last 2 columns of table 1).

DPN depressed the oxidation of succinate. This is similar to the findings with the Keilin and Hartree (1940) heart muscle preparation and also to the more recent findings of Tyler (1955a) with homogenates of heart, kidney, and brain. This depression is due to DPN increasing the formation of the actual inhibitor, oxalacetate, by stimulating the oxidation of fumarate and malate in the sequence: succinate to fumarate to malate to oxalacetate (Keilin and Hartree, 1940). Tyler (1955a) found that 0.003 M magnesium relieved to some extent the DPN inhibition of succinate oxidation in kidney and heart. In our experiments with gut epithelial residues, while the final DPN concentration was 0.001 M as in Tyler's work, the concentration of *added* magnesium was much higher (0.0067 M) and yet DPN had a considerable inhibitory effect. This different result could easily be due to other differences in the composition of the tissue preparations and reaction media, since not only formation but also metabolism and metal ion complexing of the inhibitor (oxalacetate) may influence the results obtained with DPN (Keilin and Hartree, 1940; Tyler, 1955a, 1955b).

TABLE 2

Failure of oxidation of malate to improve the oxidation of acetoacetate and certain fatty acids

Substrate*	Oxygen uptake, μl/mg N/hr†			
	Oxidized separately			Substrate and malate oxidized in same flask
	Substrate	Malate‡	Sum	
Acetate	15	52	67	62
Acetoacetate	48	67	115	110
Butyrate	24	67	91	57
Octonoate, 18 μmole	20	67	87	24
Crotonate	13	24	37	22

*30 μmole per flask except where otherwise noted.

†Corrected and calculated as in table 1.

‡10 μmole per flask except that 3 μmole were used in the acetate experiment.

Each line is for one experiment typical of the results for each substrate (except that the crotonate experiment is the only one done with this substrate), in each of which the oxidation of substrate alone was significant. The results shown for acetoacetate, butyrate and octanoate all were obtained in the same run. Three μmole DPN in each flask; other conditions as in text.

DPN enabled the fairly vigorous oxidation of all three tricarboxylic acids (citrate, *cis*-aconitate, isocitrate) to proceed. It stimulated the oxidation of glutamate, fumarate, malate and β-hydroxybutyrate in all experiments in which it was tested. DPN had little or no effect on the initial rate of oxidation of α-ketoglutarate but helped a little to prolong oxidation (figure 1).

Effect of TPN. In the experiment in table 1 in which the rate of oxidation of citrate was 0 without added pyridine nucleotide and 64 with 3 μmole of DPN added, a rate of 83 was obtained with 3 μmole of TPN added, and a rate of 114 with 3 μmole each of DPN and TPN. Whether the effect of the combination was due to a summation of different effects of the two cofactors or merely to the

higher total level of pyridine nucleotide is not known. Perhaps the residues contain both a TPN-linked and a DPN-linked isocitric dehydrogenase, as in heart (Plaut and Sung, 1954, 1955) and liver (Ernster and Navazio, 1956).

Oxidation of acetoacetate and fatty acids.—The oxidation of the last five compounds listed in table 1 was tested only in the presence of DPN. A slow but significant oxidation of acetoacetate was observed. The oxidation of acetate, crotonate, butyrate, or octanoate sometimes was insignificant, but in other experiments proceeded very slowly for about 10 min before failing completely. Lowering the level of acetoacetate to 0.003 M or of butyrate or octanoate to 0.001 M was tried since high levels of octanoate had been shown to be deterimental to washed residues of liver (Lehninger, 1945), but this only resulted in failure of the little oxidation which did occur with the higher levels of these compounds. Attempts to improve the oxidation by addition of up to 10 μmole per flask of cosubstrates such as malate (table 2), oxalacetate, or ketoglutarate generally were unsuccessful, since the uptakes during simultaneous oxidation of substrate and cosubstrate did not exceed the sum of the uptakes in the separate oxidations. Octanoate (0.003 M) depressed the oxidations of added cosubstrates markedly, and butyrate (0.01 M) usually depressed them slightly; this is shown for malate as cosubstrate in table 2.

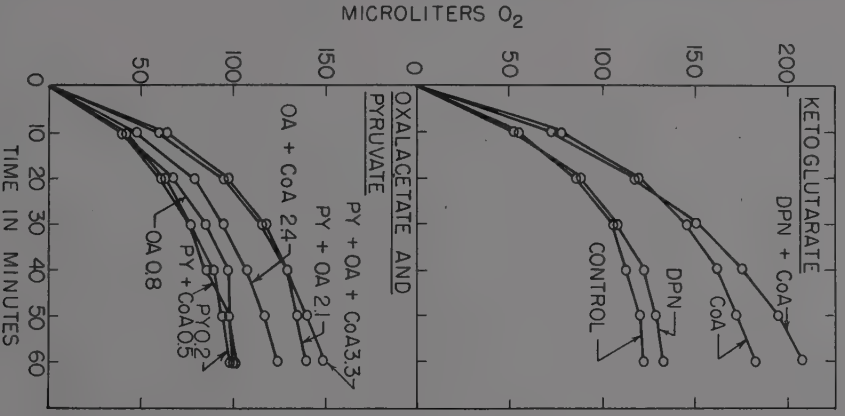


FIGURE 1. Effects of additions of certain cofactors on oxidation of certain substrates and on citrate formation by washed residues of rat small gut epithelium. The experiments graphed are those in which the most active respiration occurred with the respective substrates in the standard system, with 30 μmole of α-ketoglutarate or of pyruvate (PY) or 10 μmole of oxalacetate (OA) used per flask, and 3 μmole DPN or 1 μmole CoA added as indicated. The quantity of residue added per flask contained 1.3 mg of nitrogen in the ketoglutarate experiment and 1.5 mg of nitrogen in the oxalacetate and pyruvate experiment. All oxygen uptake values have been appropriately corrected for endogenous uptake. The numbers on the curves in the oxalacetate and pyruvate experiment refer to the μmoles of citrate formed during 70 min (i. e., 10 min equilibration plus 60 min of oxygen uptake measurements); they have been corrected for endogenous citrate formation of 0.1 and 0.2 μmole in the absence and presence of added CoA, respectively.

Oxidation of β-hydroxybutyrate.—During the oxidation of DL-β-hydroxbutyrate in the presence of DPN, acetoacetate accumulated in the reaction vessel; e.g., during the 10-min thermal equilibration period in one experiment, during which substrate was present in the flasks but oxygen uptake was not measured, about 1.4 μmole of acetoacetate accumulated. In the next 10-min period, 0.8 μmole of acetoacetate accumulated while 2.6 μatoms of oxygen were consumed. Thus, the amount of acetoacetate which accumulated during the 10-min period after

equilibration was not sufficient to account for all of the oxygen consumed during the same time period, if one assumes that the one-step oxidation of D-β-hydroxybutyrate to acetoacetate was the only reaction occurring. However, it was shown recently that tissues vary considerably in the ability to oxidize the stereoisomers of β-hydroxybutyrate (McCann, 1957). From our work with only the DL mixture, it is impossible to decide whether both or only one of the isomers is being oxidized and whether different pathways for the oxidation of the D and L isomers may be operating in our epithelial residues as in liver mitochondria (Lehninger and Greville, 1953).

Effect of CoA on oxidation of α-ketoglutarate.—The occasional failure of α-ketoglutarate to be oxidized even in the presence of added DPN appeared sometimes to be due, at least partly, to a low level or a rapid inactivation of reduced CoA in the preparations. For example, in the one experiment in which no uptake of oxygen was found with ketoglutarate in the presence of DPN, it was found that CoA (1 μmole) raised the uptake slightly to 18 and glutathione (30 μmole) had no effect, but CoA plus glutathione raised the uptake to 95, after the appropriate endogenous uptake for each cofactor combination was subtracted. However, in another similar experiment in which low uptakes were observed, neither CoA nor CoA plus glutathione was helpful; so, it appears that other limitations on ketoglutarate oxidation may be present occasionally. The effect of adding CoA was studied also in two preparations which were active to start with; the experiment in which the greatest uptakes were observed for ketoglutarate in the standard system is graphed in figure 1. In this case, CoA stimulated the oxidation initially and also prolonged the oxidation, whereas DPN had no effect initially but later helped to prolong oxidation especially in the presence of CoA; the CoA effect was repeatable with another good but somewhat less active preparation.

Formation of citrate.—The finding that *added* pyridine nucleotide was required for appreciable oxidation of added citrate but not for oxidation of pyruvate or oxalacetate by the residues, permitted a study of citrate formation under conditions which were expected to favor maximum accumulation of this metabolite. This was done in one experiment carried out on the preparation which oxidized pyruvate most rapidly, and the results are shown in figure 1. The beneficial effects of CoA on oxalacetate oxidation and on formation of citrate particularly from oxalacetate or from pyruvate plus oxalacetate are evident. These results support the impression gained from the ketoglutarate oxidation studies that even the oxidatively most active residues may be somewhat low in CoA or may inactivate this cofactor rapidly.

General discussion.—Under appropriate conditions, rat small gut epithelial residues catalyzed the oxidation of the various substrates of the Krebs cycle and of some other related compounds and catalyzed also the synthesis of citrate starting from oxalacetate or from oxalacetate plus pyruvate. These findings are consistent with the idea that the Krebs cycle with certain contributing reactions may operate in gut epithelium as in many other tissues which have been studied. On the other hand, any appreciable oxidation of several fatty acids by this tissue was not found using our standard system supplemented with DPN, even when a substrate of the Krebs cycle was cooxidized with the fatty acid. It is uncertain whether the epithelium is intrinsically low in one or more of the enzymes needed for fatty acid catabolism or whether there is some other limitation on fatty acid oxidation (perhaps insufficient CoA) in the residue preparations under our conditions.

SUMMARY

The preparation of washed residues of rat small intestinal epithelium in 0.25 M mannitol is described. These preparations exhibited no or low endogenous oxidative activity in our standard system containing buffer, phosphate, magnesium,

ATP and cytochrome *c*. They showed a somewhat higher endogenous activity when DPN was added.

The residues oxidized succinate, fumarate, malate, oxalacetate, pyruvate, glutamate, α-ketoglutarate, β-hydroxybutyrate and isocitrate in most or all experiments, and also oxidized citrate in some experiments to a slight extent.

The effect of adding DPN or CoA was tested for some of the substrates with a few of the residue preparations. The addition of DPN depressed the oxidation of succinate markedly. DPN enabled the oxidation of *cis*-aconitate to proceed, and considerably stimulated the oxidation of citrate, isocitrate, glutamate, fumarate, malate, and β-hydroxybutyrate. DPN stimulated the oxidation of α-ketoglutarate to a lesser extent and the effect was not always demonstrable. CoA addition stimulated both the oxidation of α-ketoglutarate in several experiments and the formation of citrate from added precursor substances in one experiment.

In the presence of DPN, acetoacetate was oxidized slowly but definitely. Attempts to oxidize acetate, crotonate, butyrate and octanoate in the presence of DPN resulted in failure or else in low but definite oxygen uptakes in different experiments. Reduction in the levels of certain of the acids or cooxidation of acids of the Krebs cycle did not improve the oxidation of these substances.

REFERENCES

Adler, E., H. v. Euler, G. Günther, and **M. Plass.** 1939. *Iso*citric dehydrogenase and glutamic acid synthesis in animal tissues. Biochem. Jour. 33: 1028–1045.

Barkulis, S. S. and **A. L. Lehninger.** 1951. Myokinase and the adenine nucleotide specificity in oxidative phosphorylations. Jour. Biol. Chem. 190: 339–344.

Buffa, P. and **R. A. Peters.** 1949. The *in vivo* formation of citrate induced by fluoroacetate and its significance. Jour. Physiol. 110: 488–500.

Darlington, W. A. and **J. H. Quastel.** 1953. Absorption of sugars from isolated surviving intestine. Arch. Biochem. & Biophys. 43: 194–207.

Dickens, F. and **H. Weil-Malherbe.** 1941. Metabolism of normal and tumour tissue. 19. The metabolism of intestinal mucous membrane. Biochem. Jour. 35: 7–15.

Ernster, L. and **F. Navazio.** 1956. The cytoplasmic distribution of *isocitric* dehydrogenases. Exper. Cell Research 11: 483–486.

Hele, M. P. 1953. The phosphorylation and absorption of sugars in the rat. 1. Hexokinase activity in the intestinal mucosa. Biochem. Jour. 55: 857–863.

Johnson, W. A. 1939. Aconitase. Biochem. Jour. 33: 1046–1053.

Keilin, D. and **E. F. Hartree.** 1940. Succinic dehydrogenase-cytochrome system of cells. Intracellular respiratory system catalysing aerobic oxidation of succinic acid. Proc. Royal. Soc. (London) B 129: 277–306.

Krebs, H. A. and **L. V. Eggleston.** 1945. Metabolism of acetoacetate in animal tissues. 1. Biochem. Jour. 39: 408–419.

Lardy, H. A. and **H. Wellman.** 1952. Oxidative phosphorylations: Role of inorganic phosphate and acceptor systems in control of metabolic rates. Jour. Biol. Chem. 195: 215–224.

Lehninger, A. L. 1945. On the activation of fatty acid oxidation. Jour. Biol. Chem. 161: 437–451.

——— and **G. D. Greville.** 1953. The enzymic oxidation of *d*- and *l*-β-hydroxybutyrate. Biochim. & Biophys. Acta 12: 188–202.

McCann, W. P. 1957. The oxidation of ketone bodies by mitochondria from liver and peripheral tissues. Jour. Biol. Chem. 226: 15–22.

Moinuddin, J. F. and **J. F. Cushing.** 1957. Oxidative rates of homogenates of rat small intestinal epithelium. Effects of fasting and intestinal level. Ohio Jour. Sci. 57: 224–228.

Natelson, S., J. B. Pincus, and **J. K. Lugovoy.** 1948. Microestimation of citric acid; a new colorimetric reaction for pentabromoacetone. Jour. Biol. Chem. 175: 745–750.

Plaut, G. W. E. and **K. A. Plaut.** 1952. Oxidative metabolism of heart mitochondria. Jour. Biol. Chem. 199: 141–151.

——— and **S.-C. Sung.** 1954. Diphosphopyridine nucleotide isocitric dehydrogenase from animal tissue. Jour. Biol. Chem. 207: 305–314.

——— and ———. 1955. Diphosphopyridine nucleotide isocitric dehydrogenase from animal tissues. In: Colowick, S. P. and N. O. Kaplan, editors, Methods in Enzymology I: 710–714. Academic Press, Inc., New York.

Ponz, F. and **M. Lluch.** 1955. Coupling of cell metabolism and active transport in glucose absorption by the intestine. Rev. Espan. de Fisiol. 11: 267–275.

Rose, R. L. and **J. W. Archdeacon.** 1953. The respiration of rat small intestine as affected by various substances. Trans. Kentucky Acad. Sci. 14: 17–19.
Tyler, D. B. 1955a. Effect of ethylenediamine tetracetic acid, magnesium and calcium on succinate and keto acid metabolism. Proc. Soc. Exper. Biol. & Med. 88: 333–339.
———. 1955b. Effect of metal ions and adenosine triphosphate on an oxalacetate-inhibited succinoxidase activity. Jour. Biol. Chem. 216: 395–403.
Westerfeld, W. W. and **D. A. Richert.** 1954. The xanthine oxidase factor (molybdenum). Ann. N. Y. Acad. Sci. 57: 896–904.

PETROVA HOUSERI, A NEW PITCH-NODULE MOTH FROM EASTERN NORTH AMERICA

WILLIAM E. MILLER†
Ohio Agricultural Experiment Station, Wooster

During a general study of pine-feeding Lepidoptera in Ohio, I discovered a species of *Petrova* which is apparently new to science. This species is here described as *P. houseri* in honor of Professor John Samuel Houser, late chief of the Entomology Department at the Ohio Agricultural Experiment Station, who for many years maintained an active interest in insects affecting shade and forest trees.

Petrova houseri, new species

Figures 1 to 5

Wingspread 14.5 mm.

Labial palpus white. Head dirty white except for dark gray scales around antennal bases, and a poorly defined bar of dark gray scales across front of head just above antennal bases. Collar and patagium with dark gray white-tipped scales.

Thorax clothed with dark gray scales, most being tipped with white. Legs gray with white bands. Abdomen dark gray above and beneath, dirty white along sides.

Forewing superficially exhibiting a rough checkerboard pattern of light and dark brown areas; the light areas composed chiefly of orange colored scales, and the dark areas chiefly of dark brown and blackish scales (as in the paratype in fig. 1). Scatterings of metallic gray scales present in outer ¾ of wing loosely arranged in 4 crossbands spaced at nearly equal intervals. Fringe of forewing composed of gray scales tipped with white. A line of dark brown and dark gray white-tipped scales overlapping base of fringe, producing the superficial effect of a thin white line and a thicker brown line running along fringe base. Hind wing brown with light gray fringe.

Comparison of the six paratypes with the holotype shows variation as follows: the bar across the head, as well as the dark scales around antennal bases, may be nearly absent. The metathoracic leg can be mostly dirty white, with white banding occurring on the tarsal segments only. An abundance of scattered white scales may lighten the superficial coloration of the forewings of some specimens. Also, the metallic element in some may be nearly absent.

†Now with the Forest Service, U. S. Department of Agriculture; Lower Peninsula Forest Research Center, Michigan State University, East Lansing, Michigan.

The species is described from the male holotype which has label data as follows: "Veto, Wash. Co., Ohio; VI.18.54; Ex *Pinus echinata*; W. E. Miller, Collr." Each paratype has "Ex *Pinus echinata*" and "W. E. Miller, Collr." labels, and other labels as follows: 3 males, 2 with labels "Veto, Wash. Co., Ohio, VI.17.54" and 1 with "Veto, Wash. Co., Ohio, Em.VI–56"; 3 females with labels "Wash. Co., Ohio, Em.VI–54"; "Wash. Co., Ohio, VI.24.53"; and "Veto, Wash. Co., Ohio, VI–1956."

The type locality is the southeast ¼ of Section 22 of Dunham Township (1 and ½ miles south of the village of Veto), Washington County, southeastern Ohio.

The holotype is deposited in the U. S. National Museum (Cat. No. 64389). Two paratypes are deposited in the American Museum of Natural History, and 1 paratype each in the U. S. National Museum and the collections of the Ohio Agricultural Experiment Station, The Ohio State University, and Michigan State University.

Petrova houseri seems to be related closest to *P. metallica* (Busck) and *P. luculentana* (Heinrich). The two relatives occur in the West and are probably the same species (Heinrich, 1923), but they have never been formally synonymized. *P. houseri* differs from *P. metallica* and *P. luculentana* most importantly in the

FIGURE 1. Adult female (paratype) of *Petrova houseri.*

shape of the male harpe (fig. 2, 3), a character which was constant for each species in all male genitalia seen (4 *P. houseri* males from Ohio; 4 *P. metallica* males from Montana; and 1 *P. luculentana* male (holotype) from Colorado). There are less striking differences between the female genitalia (ostia) of *P. houseri* and *P. metallica—P. luculentana* (4 *P. houseri* females from Ohio seen; 5 *P. metallica* females from British Columbia; and 2 *P. luculentana* females (paratypes) from Colorado). Figures 4 and 5 show the most important features of *P. houseri* female genitalia.

Petrova metallica and *P. luculentana* appear to vary in coloration much the same way that *P. houseri* does. In general, however, *P. houseri* has less of a metallic element and more of an orange element in its forewing then either of the other two. It is a smaller insect, the wing-spread of type series males averaging 13.4 mm, and of type series females, 15.2 mm, compared to 18.0 mm for the *P. metallica* males and 18.0 mm for the *P. metallica* and *P. luculentana* females seen.

Petrova houseri is the undescribed species of *Petrova* mentioned by Miller and Neiswander (1955, 1956) as being host specific on shortleaf pine, *Pinus echinata* Miller, and corresponding in distribution with the ranges of native pines in Ohio.

(Nomenclature of pines here follows Little, 1953). The insect is geographically isolated from its close relatives by the geographic isolation of *Pinus echinata* from *P. ponderosa* Lawson and *P. contorta* Douglas, hosts of *Petrova metallica* and *P. luculentana* (Heinrich, 1923). *Petrova houseri* is known thus far only from Ohio, but it undoubtedly occurs over a wider area. The larva feeds on current growth twigs on which it makes a blisterlike pitch nodule. The life cycle is univoltine and adults are present in June. Details of *P. houseri* biology will appear in another paper now in preparation.

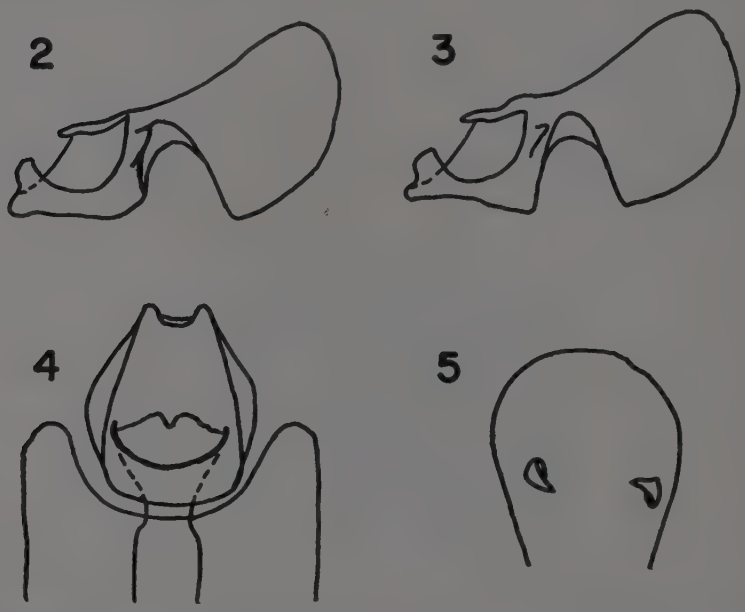


FIGURE 2. Harpe of *Petrova houseri*.
FIGURE 3. Harpe of *Petrova metallica* (Busck). The harpe of *P. luculentana* (Heinrich) is similar.
FIGURE 4. Ostium with certain associated structures of *P. houseri*.
FIGURE 5. Bursa copulatrix and double signum of *P. houseri*.

ACKNOWLEDGMENTS

The writer is indebted to Dr. J. F. Gates Clarke of the U. S. National Museum and to Dr. T. N. Freeman of the Canadian National Collection who arranged loans of *Petrova metallica* and *P. luculentana* material.

LITERATURE CITED

Heinrich, C. 1923. Revision of the North American moths of the sub-family Eucosminae of the family Olethreutidae. U. S. Nat. Mus. Bull. 123: 1–298.
Little, E. L. 1953. Check list of native and naturalized trees of the United States (including Alaska). (U. S.) Agric. Handbook 41: 1–472.
Miller, W. E. and **R. B. Neiswander.** 1955. The biology and control of the European pine shoot moth. Ohio Agric. Exper. Sta. Res. Bull. 760: 1–31.
——— and ———. 1956. The pitch twig moth, and its occurrence in Ohio. Ohio Agric. Exper. Sta. Res. Bull. 779: 1–24.

STUDIES ON MARINE BRYOZOA. XII. *PORELLA*

MARY D. ROGICK

Department of Biology, College of New Rochelle, New Rochelle, New York

The purpose of the present study is (a) to report two species of *Porella* (Family Smittinidae, Order Cheilostomata, Phylum Bryozoa) from new Antarctic localities, (b) to bring their synonymy up to date, and (c) to add new morphological data to define more clearly their key characters.

The species are from the same bryozoan collection made by the U. S. Navy's 1947–48 Antarctic Expedition as were those of previous studies of this series. Most grateful acknowledgment is due to the National Science Foundation for its very generous and long continued support of this and of previous studies.

Several members of the Family Smittinidae have already been reported (Rogick, 1955, 1956) but the affinities of the two present species were not recognized at that time because one of them had for a long time been known as *Lepralia marginata* while the other so resembled the genus *Cellepora* in general appearance and growth habit that they were put aside for study with the Lepralioid and Celleporid genera. It was only after detailed study that their Smittinid characters became apparent.

GENUS *PORELLA* GRAY 1848

Diagnosis.—Based on Osburn's 1952 and Harmer's 1957 accounts. Frontal a pleurocyst, usually thick and nonperforate except for areolar pores (see fig. 2 A). Suboral avicularium (fig. 2 B) rounded, median, directed proximally, its chamber (fig. 15 C) narrowly connected to a lateral areola on each side. Lyrula absent (fig. 1 R) or slightly developed (fig. 18 M). Ovicell (fig. 2 S) globose, hyperstomial, imperforate, later immersed by secondary calcification (fig. 1 S).

Genotype: *Millepora compressa* Sowerby 1805, selected by Norman 1903, p. 112.

Porella marginata (*Calvet*) *1909*
(*Figures 1–7, 14, 15*)

Synonymy and previous records:

1909. *Lepralia marginata.* Calvet, pp. 24–25; Pl. 2, fig. 7–9. Species was described from a single colony. Ovicell, zooecia, operculum and mandible illustrated. From Bay of Biscoe, 110 meters, on calcareous tube of Annelid.

1924. *Lepralia marginata.* Thornely, p. 11. Found uni- and bilaminate colonies and zooecia with small process on back wall for attachment. From Commonwealth Bay, Sta. 12, 110 fathoms.

1928. *Lepralia marginata.* Livingstone, pp. 6, 8, 9, 10, 60; Pl. 7, fig. 4, 6. Photographs of general appearance of ovicelled and nonovicelled parts of colony. Account mentions strikingly large hinge teeth but does not picture them. Commonwealth Bay (Adelie Land and other stations), 55–157 fathoms.

1952. *Lepralia marginata.* Vigeland, p. 9. Distribution only. From Graham Land, Port Lockroy, 120 meters, on stones and algae.

1957. *Lepralia marginata.* Rogick, p. 8, incidentally mentioned as occurring along with *Phylactellipora lyrulata* at Marguerite Bay, Antarctica Sta. 225.

The above are the only records of this species to date.

Diagnosis.—Zooecial front subhexagonal, finely verrucose (fig. 3, 5), bordered by rounded, closely placed areolae except distally. Orifice (fig. 3 R) straight proximally, arched distally, provided with prominent lateral condyles (fig. 15 F). Avicularium suboral, subcircular, median, placed a slight distance below lower lip (fig. 15 B) and proximally oriented. Avicularial mandible (fig. 6) subsemicircular. Ovicell salient, globose, verrucose, with uncalcified

median pore or pit (fig. 3 T), but becomes completely immersed by secondary calcification. Mural rims (O of fig. 1) of neighboring zoids meet across its front in seams. Hooked processes (fig. 14) on dorsal (basal) surface sometimes.

Morphology.—Considering that only a colony fragment was available to him Calvet illustrated the species admirably. The condyles (fig. 15 F) inside the orifice were not noticed either by Calvet or Thornely but Livingstone reported their presence although he did not figure them. The present account adds further information on this species as measurements, variations in colony appearance in advanced secondary calcification, tentacle sheath and polypide.

Measurements.—The first figures are the minimum, the next the maximum, the last (in parentheses) are the average of ten readings. Measurements are in millimeters. Abbreviations:—L, length; W, width.

0.936–1.368 (1.218) L Zooecia
0.317–0.518 (0.452) W Zooecia
0.145–0.160 (0.159) L Operculum
0.162–0.181 (0.171) W Operculum
0.374–0.418 (0.392) L Ovicell
0.360–0.461 (0.408) W Ovicell
0.087–0.145 (0.111) L Avicularium
0.072–0.101 (0.085) W Avicularium
0.058–0.109 (0.089) L Mandible
0.058–0.087 (0.079) W Mandible

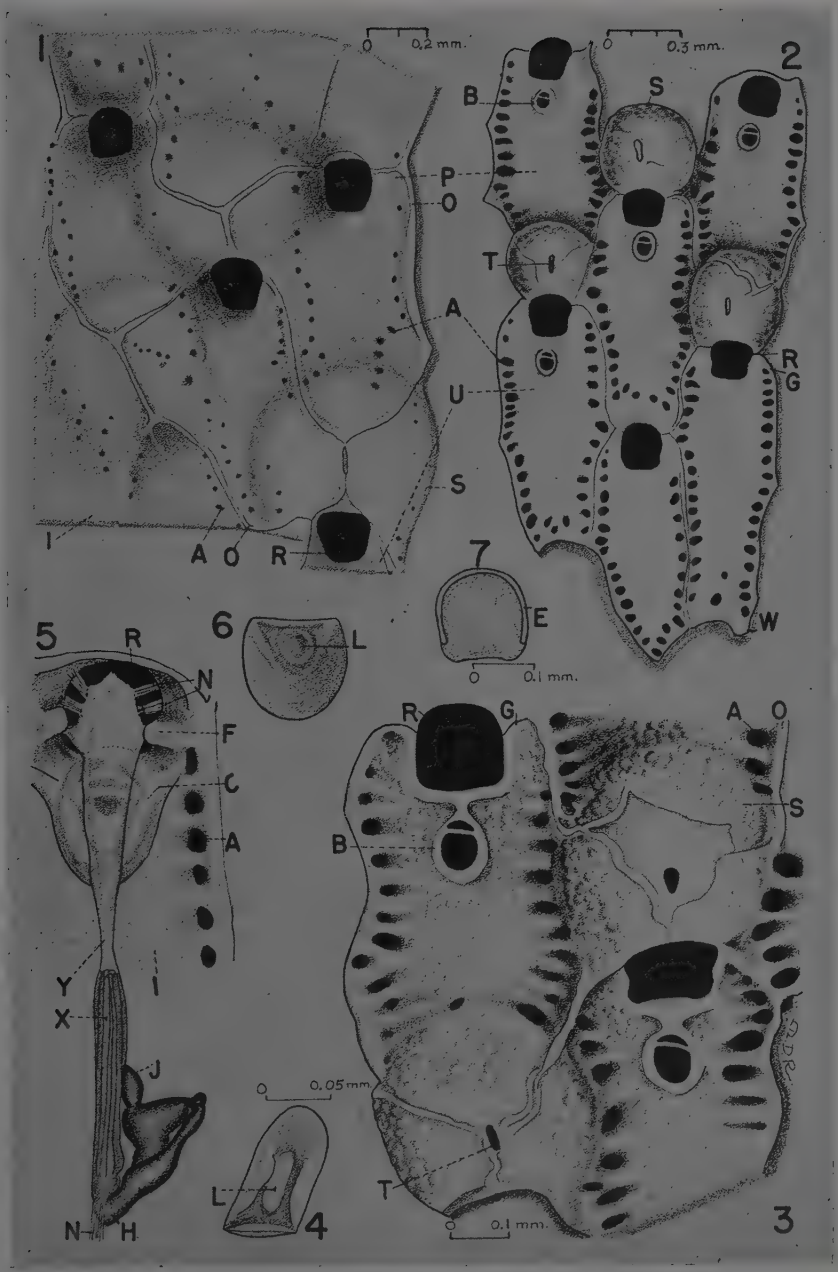
KEY TO ABBREVIATIONS ON FIGURES

A—Areolae
B—Avicularium
C—Avicularial chamber
D—Basal wall of zooecium
E—Chitinous rim of operculum
F—Condyle or articulating ledge
G—Distal end of zoid or zooecium
H—Esophagus of polypide
I—Frontal wall of zooecium
J—Rectum of polypide
K—Lateral wall of zooecium
L—Lucida
M—Lyrula or median tooth
N—Muscles
O—Mural rim or salient line outlining zooecial boundaries
P—Nonovicelled zooecium
Q—Oral spine or spines around orifice
R—Orifice
S—Ovicell
T—Ovicell "pore" or pit
U—Ovicelled zooecium
V—Peristomial wing
W—Proximal end of zooecium
X—Tentacles
Y—Tentacular sheath
Z—Umbo

EXPLANATION OF FIGURES IN PLATE I

All figures on this plate are of *Porella marginata* (Calvet) and were drawn with the aid of a camera lucida.

1. Frontal surface of two nonovicelled and three ovicelled zooecia in an old part of a colony. The orifice of the lower left ovicelled zooecium is completely overgrown. The salient mural rims of the frontal walls of the three neighboring zooecia meet over each ovicell in a Y-shaped seam. Areolar pores which mark the true lateral boundaries of zooecia are fast becoming obliterated. Avicularia are either overgrown or wanting in this part of the colony. Drawn to the scale above.
2. Frontal surface of three ovicelled and three nonovicelled zooecia of a younger colony. Ovivells are not yet overgrown. Drawn to the scale above.
3. Detail of two ovicells and two zooecia. Upper right ovicell shows approximating frontal covering. Drawn to the scale below it.
4. Avicularial chitinous mandible with elliptical lucida and two lateral thickenings. Drawn to the scale directly above it.
5. Inner surface of frontal wall. Polypide is suspended by muscles and tentacular sheath from the operculum region. Operculum is blackened in drawing. Beneath the operculum and behind the long transparent tentacular sheath is visible the avicularial chamber. Drawn to the figure 3 scale.
6. Another avicularial mandible, drawn to figure 4 scale.
7. Operculum, drawn to the scale immediately below it.


1
0 0.2 mm.
P
O
A
U
S
I
A O R
2
0 0.3 mm.
B
S
T
R
G
W
7
E
0 0.1 mm.
5
R
N
F
C
A
Y
X
I
J
N H
6
L
4
0 0.05 mm
L
3
R G
A O
S
B
T
0 0.1 mm.

Zoarium.—The biggest colony (zoarium), 40 mm long and 21 mm at widest diameter, was hourglass shaped as if it had grown around something. The remaining colony fragments were unilaminar ivory-colored chips measuring from 18 mm by 32 mm downward. Colony surface is quite smooth, neatly patterned. In old colonies smooth areas appear here and there where orifices and frontal pores have been obliterated or covered over by secondary calcification (fig. 1, lower left zoid).

Zooecia.—Zooecia are longer than wide, clearly marked off frontally from each other by a salient rim in young zoids (fig. 2, 3) but not in heavily calcified old zoids. Old zooecial fronts fuse into a common flat crust which is punctured here and there by zooecial orifices and rows of reduced areolar pores (fig. 1). The front of young zooecia is thin, faintly convex, with pebbled (reticulate or verrucose) markings (fig. 5, 15), nonporous except for the closely set areolae which are separated by short ribs. The areolae of old heavily calcified zooecia elongate into tubes of reduced diameter and the ribs lose their identity (fig. 1).

A zoid's frontal wall does not distally encircle its own orifice but stops at the sides of the orifice (fig. 3, upper left zoid).

The lateral zooecial wall has about eight widely spaced pores.

The back (dorsal) wall is slightly convex and provided with one or more median hooked attachment processes (fig. 14) that may wear down or break off into pores.

Orifice.—The orifice is placed at the distal extremity of the frontal wall. It is bounded proximally and laterally by its own frontal wall, distally and laterally by the frontal wall of the next distal zoid.

EXPLANATION OF FIGURES IN PLATE II

All figures were drawn with the aid of a camera lucida.

8. Young 7-spined zooecium of *P. marsupium* from Sta. 226. Avicularium a bit large as compared with other zoids. Avicularial umbo not yet sufficiently developed. Drawn to the scale above it.

9. Frontal view of three zooecia with unfinished developing ovicells and one non-ovicelled zooecium of *P. marsupium* from Sta. 226. Umbones are of variable size. Drawn to the figure 8 scale.

10. View of front and lateral walls of two young *P. marsupium* zooecia, the upper one ovicelled the lower one not. Some spines of the lower one are broken off at the base. The spoutlike aviculiferous umbo, though prominent, is not yet as fully developed laterally as that of figure 12. Lateral wall pores have been omitted from the drawing because they were obscured by adjacent zooecia, so the lateral walls were left in a diagrammatic condition. From Sta. 104. Drawn to the figure 8 scale.

11. Orifice region detail of young *P. marsupium* zoid from Sta. 226. Zoid is slightly older than that of figure 8, with a better developed aviculiferous umbo but with a proportionately smaller avicularium. Drawn to the scale directly below it. Lyrula and condyles faintly visible.

12. Side view of frontal wall of an old ovicelled *P. marsupium* zooecium and the ovicell and peristome of another. The umbo has developed lateral peristomial flaps approximating the ovicell. From Sta. 190.

13. An old ovicelled zoid of *P. marsupium* with roughened "beaded" frontal wall. Spine remnants at sides of ovicell. Peristome not as well developed as in preceding figure. From Sta. 190. Drawn to the figure 8 scale.

14. The basal, back or dorsal walls of four *P. marginata*. Two pointed attachment processes are intact, four have been broken off, leaving holes. From Sta. 226. Drawn to the scale directly above.

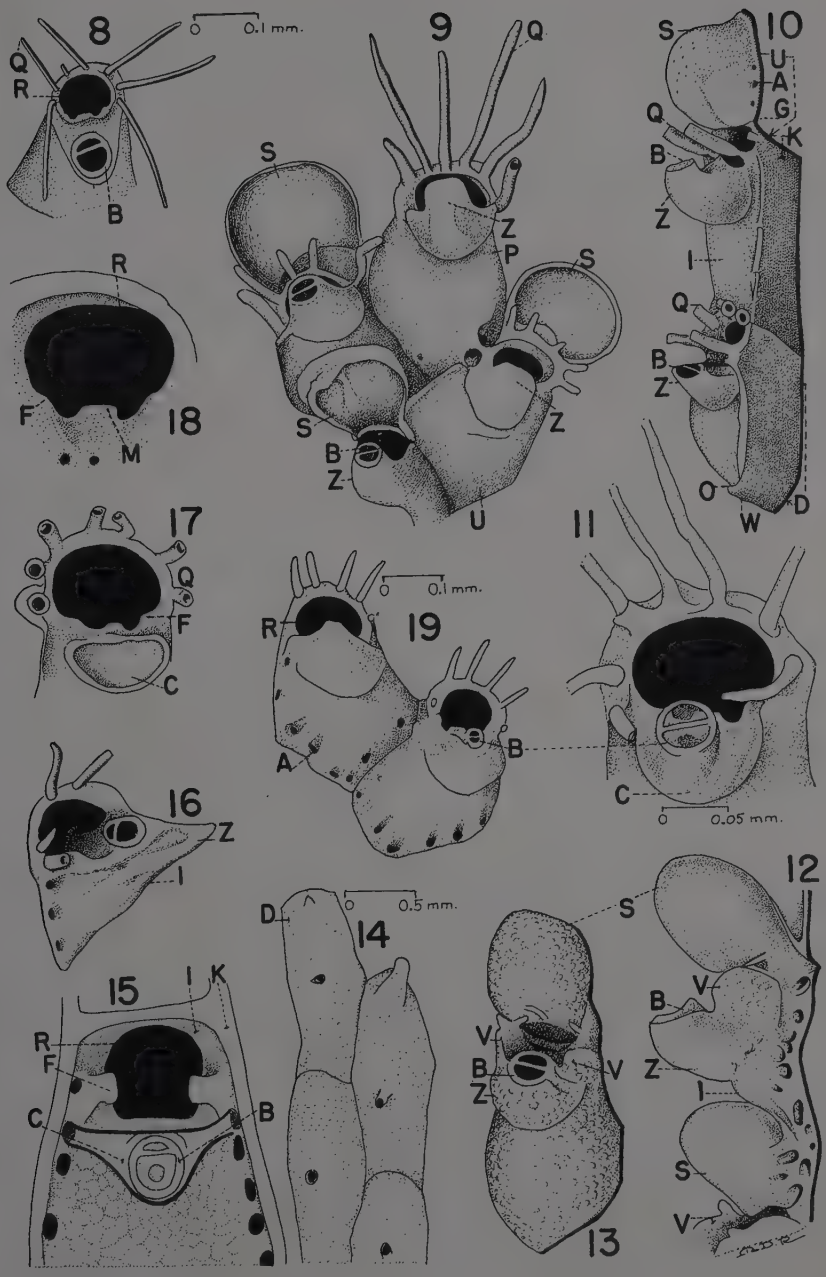
15. Inner surface of frontal wall of *P. marginata* showing orifice, condyles and the bilateral nature of the avicularial chamber. The cobbled pattern of the frontal wall is peculiarly characteristic of young zoids of this species. Drawn to the figure 19 scale.

16. *Porella marsupium* zoid with an incomplete number of spines and an unusually peaked umbo. From Sta. 240 (pebble z). Drawn to the figure 8 scale.

17. Frontal view of orifice and incomplete avicularial chamber of young *P. marsupium* from Sta. 104. The median tooth or lyrula and the lateral condyles or cardelles are evident but the umbo and avicularium have not yet developed. Drawn to the figure 11 scale.

18. Inner surface of frontal wall of *P. marsupium* from Sta. 190, showing shape of orifice and also two small pores which connect to the avicularial chamber in some zoids at least. Drawn to the figure 11 scale.

19. Two young *P. marsupium* zoids from a Sta. 240 colony. Areolae not yet obliterated by crowding or overgrowth. Spine number variable. Drawn to the scale directly above.


8
0.1 mm.
Q
R
B
9
Q
S
Z
P
S
S
B
Z
Z
U
10
S
U
A
G
K
Q
B
Z
I
Q
B
Z
O
W
D
18
R
F
M
17
Q
F
C
19
0.1 mm.
R
A
B
11
B
C
0.05 mm.
16
Z
I
15
I
K
R
F
C
B
14
0.5 mm.
D
13
S
V
B
Z
V
12
V
B
Z
I
S
V

The orifice is of the lepralioid type. The primary orifice has a hemispherical anter (distal border or portion) and a poster (proximal region) which is shorter and straighter. The lateral sides of the anter are nearly parallel. The secondary orifice (in older zoids) may be almost round or faintly squared.

Inside the orifice, generally invisible externally, are two strong rectangular or chisel-like condyles, one projecting from each lateral wall.

The operculum is shaped like the primary orifice and provided with a re-inforcing thickened chitinous rim (fig. 7) about its three sides. The operculum fits the orifice externally and articulates internally with the condyles.

Oral spines were absent. Previous workers did not find any either.

Avicularia.—One avicularium per zoid is the usual condition but occasional zoids lack an avicularium (fig. 2). It may be obliterated by secondary calcification (fig. 1). Avicularial size varies slightly but not the shape or location. Avicularia are broadly oval, their rounded beaks directed proximally. They are in the midline a short distance below the orifice, immersed in the frontal wall and parallel to the plane of the basal wall.

The avicularial chamber narrows laterally into a channel which ends at an areola on each side (fig. 15 C). The chamber contains short thick avicularial muscle bundles between which is located the vestigial avicularial polypide.

Ovicells.—The globose, hyperstomial ovicell is not closed by the operculum. In young zoids the ovicell surface is handsomely pebbled and decorated by a thin Y-shaped salient line which is formed by the mural rims of the walls of the three neighboring zoids (lateral and distal) meeting over the ovicell front. At their meeting point a membrane-covered oval pore is usually present. In old heavily calcified zoids the pore may become solidly calcified and obliterated (fig. 1) and the ovicell will no longer protrude but will be immersed in the flat common crust that erases zooecial boundaries and levels zooecial surfaces.

Orange-colored embryos were present in ovicells from Sta. 11.

Polypide.—Polypides are present in some zooecia. The tentacular sheath (fig. 5 Y) is very long, slender, thin, transparent. Two oral glands are located high up near the operculum. It was impossible to get an accurate tentacle count on older zoids but one young bud had 16 tentacles. Tentacles are long and slender (fig. 5 X).

Distribution and ecology. Porella marginata occurred in small amounts at the following USN Antarctic stations (see Rogick 1956, pp. 222–223 for fuller station details): Sta. 11 (Lat. 66° 38′ S., Long. 90° E., 150 fathoms); Marguerite Bay Stations 225, 226, 230, 234 (40 fathoms) and Case 1.

A small colony grew on the back of a live *Smittoidea evelinae* (i.e., alive at the time of collection) but other colony fragments were free from any other growths. *Porella marginata* was an unusually "clean" species.

Porella marsupium (*MacGillivray*) *1869*
(*Figures 8–13, 16–19*)

Synonymy and some previous records:

1869. *Lepralia marsupium.* MacGillivray, p. 136. A short description but no figure. From Victoria, Australia.

1879. *Lepralia marsupium.* MacGillivray, pp. 22–23; Pl. 35, fig. 4–4b. Short description. Figures very small with distinctive characters of the 1869 species inadequately illustrated.

1888. *Aimulosia australis.* Jullien, pp. I.59–I.60; Pl. 1, fig. 5 (ovicells and zooecia). Tierra del Fuego, Hoste Isle, Orange Bay.

1895. *Porella marsupium.* MacGillivray, pp. 91–92; Pl. 12, fig. 9a but not Fig. 9 whose lyrula seems too wide.

1904. *Smittia marsupium* (part). Waters, pp. 61–62; Pl. 4, fig. 4. Lat. 70° 23′ S., Long. 82° 47′ W., 480 meters; Lat. 70° S., Long. 80° 48′ W., 500? meters.

1924. *Smittia marsupium?* Thornely, p. 14, mentions 4 or 5 spines. Commonwealth Bay, Adelie Land, 25 fathoms.

1928. *Smittina marsupium?* Livingstone, pp. 7, 65.

1952. *Porella marsupium* (part). Brown, pp. 312–314, fig. 234. Castlecliff, New Zealand. Upper Pliocene.

The following citations are not of the same species:

1881. *Porella marsupium*. Hincks, p. 123; Pl. 1, fig. 6.

1884. *Lepralia marsupium*. Busk, p. 147; fig. 44.

1957. *Smittina marsupium*. Harmer, pp. 922–923; Pl. 63, figs. 11–14.

Discussion.—Calvet (1909, pp. 30–31), Thornely (1924, p. 14), and Livingstone (1928, p. 65) reported the species from Antarctic localities but gave little or no descriptive data and no pictures or measurements of it and for these reasons their records were not included in the foregoing synonymy since this early became a controversial species. Hincks (1881), Busk (1884), and Harmer (1957) on the other hand illustrated their *marsupium* but appear to have had another species than that of MacGillivray.

The USN specimens agreed well in measurements with Brown's Castlecliff Pliocene forms, except that the orifice length (height) measurements of the USN zoids were a bit greater. Also, Brown's species had four oral spines while the USN zoids had five to seven.

Diagnosis.—Colony encrusting. Zooecia small, plump, crowded but in linear rows. Front convex, nonporous except for some small areolae (fig. 19 A). Orifice hemispherical above, contracted and with small lyrula below (fig. 18 M); five to seven oral spines (fig. 8, 9 Q). Avicularia small, rounded, oriented at a 60° angle to the plane of the orifice (approximately). Mandible semicircular. Avicularial chamber limited to region immediately around proximal orifice border. Peristome (fig. 12 V) unevenly developed. Ovicell (fig. 10, 12 S) hyperstomial, opening into the peristomie. Ancestrula with about six oral spines.

Measurements.—See page 234.

0.232–0.421 (0.328) L Zooecia
0.145–0.290 (0.228) W Zooecia
0.044–0.087 (0.059) L Avicularia
0.044–0.080 (0.059) W Avicularia
0.148–0.196 (0.170) L Ovicells
0.174–0.215 (0.197) W Ovicells
0.131–0.174 (0.147) Ovicell, front to back diameter
0.065–0.080 (0.071) L Primary orifice, untipped, just as zoids lie on their back
0.087–0.109 (0.100) W Primary orifice
0.172 L and W Ancestrula, 1 reading only.

Zoarium.—At first glance *P. marsupium* was thought to be a *Cellepora* because of its very small crowded zoids and hidden orifices but a closer study of the orifice proved it to be a *Porella*.

Only small encrusting colonies of few zoids and but a few millimeters across were found.

Zooecium.—Zooecia have a quincuncial arrangement near the center of the colony (fig. 9) but may tend to form more orderly linear rows (fig. 10, 12) when the substratum permits. The zooecial front is convex, calcareous, granulated and nonporous except for the occasional small areolae (fig. 19 A). A prominent spoutlike umbo (fig. 9, 10, 12 Z), topped by a rounded avicularium, rises just in front of the orifice. The umbo of specimens from Sta. 240z rock had a prolonged peak in front of the avicularium (fig. 16).

The umbo forms the peristome. The peristome extends around the front and sides of the orifice. At the sides the peristome may develop into an extended flap (fig. 12 V).

Young nonovicelled zoids have five to seven thin long oral spines (fig. 9 Q). In older zoids the lateral peristome grows in height replacing some of the lateral oral spines which have broken off, incorporating their bases. The ovicell begins to form on some zoids before the distal spines are lost.

Avicularium.—The umbo rises at a 60° slant, approximately, from the frontal wall. The oral avicularium is on its distal oral side, likewise at about a 60° slant, away from the orifice.

Only these small median suboral avicularia were found, one per zoid. Though somewhat variable in size the avicularia look alike. Their semicircular mandible points away from the orifice.

The umbo houses the hemispherical or crescentic avicularial chamber (fig. 11, 17 C) whose lateral extremities do not extend to lateral areolae, thus differing from some of the other

Smittinidae. In some zoids two small pores (fig. 18) occur on the inner surface of the frontal wall which forms the avicularial chamber floor. Not enough good specimens were available to check if this is a constant condition.

Orifice.—The deeply buried primary orifice is semicircular distally (almost) and contracted proximally. It has a small, low, median lyrula and slight lateral cardelles or condyles with which the operculum articulates. Busk's *L. marsupium* lacked a lyrula and its operculum was different from that of the USN specimens.

The frontal wall of the next distal zoid does not encroach upon the peristome.

Ovicell.—The bulbous hyperstomial ovicells open into the peristomie (lumen of the peristome) and are not closed by the operculum. Their opening is hidden from view because of the angle at which the ovicell is tipped forward (fig. 10, 12).

The ovicell surface is granulated, generally nonporous. In Station 240 colonies ovicells as well as umbos, tended to develop a small peak frontally.

A Station 226 colony had several ovicells each of which was half-filled by a small red embryo.

Oral spines remain for a short time about the orifice while the ovicell is developing, then break off near the base where there may be a "joint." Two spines remain for some time after the ovicell is well formed, one at each side of the ovicell distal to the peristomial flaps.

Distribution and ecology.—This species was not abundant. The small *P. marsupium* colonies came from the USN Antarctic Stations 104 of the Ross Sea Area and Stations 190, 226, 238, 240 of Marguerite Bay. It grew on various substrates: rhizoids of bryozoans or hydroids (Sta. 190, 226); sponge spicules (Sta. 190); *Notoplites tenuis* (Sta. 104, 238); rocks (Sta. 240); fragments of mollusk shell, algae and *Phylactellipora lyrulata* (Sta. 226).

LITERATURE CITED

Brown, D. A. 1952. The Tertiary Cheilostomatous Polyzoa of New Zealand. British Museum (Nat. Hist.). London. 405 pp.

Busk, G. 1884. Report on the Polyzoa collected by the H.M.S. Challenger . . . 1873–76. Part I. Cheilostomata. Repts. Sci. Results H.M.S. Challenger. Zool. 10(30): 1–216.

Calvet, L. 1909. Bryozoaires. Exped. Antarct. Franç. (1903–05) . . . Charcot. Masson et Cie. Paris. 50 pp.

Gray, J. E. 1848. List of the Specimens of British Animals in the Collection of the British Museum. Part 1. Brit. Mus. London. 173 pp.

Harmer, S. F. 1957. The Polyzoa of the Siboga Expedition, Part IV. Monographie XXVIIId, Uitkom. Zool., Bot., Oceanogr. Geol. Gebied. Nederlandsch Oost-Indië 1899–1900 H. M. Siboga. E. J. Brill, Leiden. 507 pp.

Hincks, T. 1881. Contribs. towards a general history of Marine Polyzoa. Ann. Mag. Nat. Hist. (5)8: 122–136.

Jullien, J. 1888. Bryozoaires. Mission du sci. Cap Horn 1882–83, VI, Zool. (3): I.1–I.92.

Livingstone, A. A. 1928. The Bryozoa. Supplementary Report. Sci. Repts. Australasian Antarct. Exped. 1911–14 . . . Mawson. Ser. C, Zool. Bot., IX(1): 1–93.

MacGillivray, P. 1869. Descriptions . . . Australian Polyzoa. Trans. Roy. Soc. Victoria, IX: 126–148. (1868).

1879. Polyzoa, in McCoy's Prodromus of the Zool. of Victoria, Melbourne. Decade 4, pp. 21–35.

———. 1895. A monograph of the Tertiary Polyzoa of Victoria. Trans. Roy. Soc. Victoria, n. ser., IV: 1–166.

Norman, A. M. 1903. Notes on the Natural History of East Finmark, Polyzoa. Ann. Mag. Nat. Hist. (7)12: 87–128.

Osburn, R. C. 1952. Bryozoa of the Pacific Coast, Part 2. Univ. of So. Calif. Press, Allan Hancock Pacific Exped., 14(2): 271–611.

Rogick, M. D. 1955. Emballotheca . . . Trans. Amer. Micr. Soc. 74(2): 103–112.

———. 1956. Bryozoa of the U. S. Navy's 1947–48 Antarctic Exped., I–IV. Proc. U. S. Nat. Mus., 105(3358): 221–317.

——— . 1957. Studies on Marine Bryozoa. IX *Phylactellipora*. Ohio Jour. Sci. 57(1): 1–9.

Thornely, L. 1924. Polyzoa. Australasian Antarct. Exped. 1911–14, Ser. C, Zool. Bot., VI (6): 1–23.

Vigeland, I. 1952. Antarctic Bryozoa. Det Norske Vid.-Akad. Oslo. Sci. Results Norweg. Antarct. Exped. 1927–28, No. 34, pp. 1–16.

Waters, A. W. 1904. Bryozoa. Exped. Antarct. Belge, Result. Voy. S. Y. Belgica 1897 99 . . . de Gomery, Rapp. Sci. Zool., 114 pp.

ANNUAL REPORT OF THE OHIO ACADEMY OF SCIENCE
1959

Organized 1891 Incorporated 1892
Affiliated with the American Association for the Advancement of Science

OFFICERS AND COMMITTEES FOR 1959

President
DWIGHT M. DELONG

Secretary
GEORGE W. BURNS

Treasurer
ELTON F. PADDOCK

Treasurer-Elect
ROBERT M. GIESY, III

Director of Public Relations
JOHN R. COASH

Executive Secretary
KENNETH B. HOBBS

Executive Secretary, Junior Division
GEORGE G. ACKER

Executive Vice-Presidents

A. *Zoology:* C. C. DAVIS
B. *Plant Sciences:* R. W. LONG
AB. *Chm. Subsection of Genetics:* C. COHEN
C. *Geology:* R. H. DURRELL
D. *Medical Sciences:* C. G. BARBER
E. *Physics and Astronomy:* H. N. MAXWELL
F. *Geography:* H. L. HUNKER
G. *Chemistry:* F. L. JAMES
H. *Science Education:* I. SLESNICK
I. *Anthropology and Sociology:* S. NEWMAN
J. *Conservation:* E. H. DUSTMAN

Membership Vice-Presidents

A. *Zoology:* D. J. BORROR
B. *Plant Sciences:* D. S. DEAN
AB. *Vice-Chm. Subsection of Genetics:* L. O. GILMORE
C. *Geology:* R. H. BOND
D. *Medical Sciences:* R. A. KEHOE
E. *Physics and Astronomy:* P. B. TAYLOR
F. *Geography:* J. L. THOMPSON
G. *Chemistry:* E. B. ROSSER
H. *Science Education:* C. RISER
I. *Anthropology and Sociology:* F. F. MILES
J. *Conservation:* G. K. DOTSON

COMMITTEES

Executive
D. M. DELONG, Chm., G. W. BURNS, E. F. PADDOCK, G. G. ACKER, R. A. POPHAM, J. R. COASH, R. P. GOLDTHWAIT, R. W. DEXTER

Nominating
MEMBERS OF THE EXECUTIVE COMMITTEE

Program
EXECUTIVE VICE-PRESIDENTS AND THE SECRETARY, Chairman

Library
Academy Librarian, MARY PINSON, Chairman
W. P. SPENCER.....Term expires 1961
W. G. GAMBILL.....Term expires 1963

Publications
THE SECRETARY, Chairman
W. P. SPENCER.....Term expires 1961
W. G. GAMBILL.....Term expires 1963

Trustees of Research Funds
W. C. BEAVER, Chm.....Term expires 1960
H. V. KNORR.....Term expires 1961
E. H. CHERRINGTON.....Term expires 1962

Necrology

A. G. McQuate, Chm....Term expires 1960
J. T. Maddox.....Term expires 1961
H. H. M. Bowman.....Term expires 1962

Resolutions

F. O. Hazard, Chm.....Term expires 1960
K. L. Kelley.....Term expires 1961
J. H. Cooper.....Term expires 1962

Ohio Flora

T. R. Fisher, Chairman
E. L. Braun
J. A. Herrick
G. W. Blaydes
E. S. Thomas
Clara Weishaupt
J. N. Wolfe

Academy History

R. W. Dexter, Chairman

Institution and Corporation Membership

Paul Rothemund, Chairman
G. H. Crowl
E. F. Paddock

Training and Certification of Science Teachers

J. C. Gray, Chairman
R. S. Baby
J. H. Buckingham
E. E. Good
R. T. Hargrove
A. G. Lindschied
R. H. Mayhard
A. G. McQuate

Academy Representatives

On the Joint Administrative Board of The Ohio Journal of Science:

W. P. Spencer.....Term expires 1961
W. G. Gambill.....Term expires 1963

On the Council of the American Association for the Advancement of Science:

G. W. Burns; R. W. Dexter (alternate)

The Council for 1959–60

G. G. Acker
C. G. Barber
W. C. Beaver
R. H. Bond
D. J. Borror
G. W. Burns
J. R. Coash
C. Cohen
C. C. Davis
D. S. Dean
D. M. DeLong
R. W. Dexter
G. K. Dotson
R. H. Durrell
E. H. Dustman
T. R. Fisher
W. G. Gambill
R. M. Giesy
L. O. Gilmore
R. P. Goldthwait
J. C. Gray
F. O. Hazard
H. L. Hunker
F. L. James
R. A. Kehoe
R. W. Long
A. G. McQuate
H. N. Maxwell
F. F. Miles
S. C. Newman
E. F. Paddock
M. Pinson
H. L. Plaine
R. A. Popham
C. Riser
E. B. Rosser
P. Rothemund
I. L. Slesnick
W. P. Spencer
P. B. Taylor
J. L. Thompson

REPORT OF THE SIXTY-EIGHTH ANNUAL MEETING OF THE OHIO ACADEMY OF SCIENCE

The 68th annual meeting was held on the campus of Capital University April 16, 17, and 18, 1959, marking a return of the Academy to that institution after nine years. A total of 713 persons registered for meetings of the senior division. The local committee on arrangements, under the chairmanship of Dr. Robert M. Geist, did an outstanding job in providing facilities to make this meeting a real success.

The Executive Committee, the Council, and the Committee on Election of Fellows met on April 16; their reports are found elsewhere in the Annual Report. On Friday, April 17, ten sections and one subsection held meetings in the following fields: Zoology, Plant Sciences, Genetics, Geology, Medical Sciences, Physics and Astronomy, Geography, Chemistry, Science Education, Anthropology and Sociology, and Conservation. Nearly 150 research papers were presented and discussed. Highlights of the sectional meetings included a symposium on Instruction in Inorganic Chemistry and Qualitative Analysis in the Undergraduate Chemistry Curriculum, a symposium on The Thermonuclear Problem, a symposium on Diseases Transmitted by Animals to Man, a panel on the Role of Geography in Urban Development, and a symposium on Problems Resulting from Population Growth.

Throughout Friday the Junior Division sponsored the Eleventh Annual State Science Day in which 600 projects were entered by nearly 700 students from 213 schools. Sectional meetings of the Senior Division were again suspended at 11:00 AM to give all members an opportunity to view the projects and exhibits of the junior members.

The annual banquet and business meeting were held Friday evening in the Refectory. Dr. Theodore B. Myers served as toastmaster. Greetings from Capital University were

given by President Harold L. Yochum and the response was made by Dr. Rush Elliott of Ohio University. Dr. Richard P. Goldthwait, president of The Ohio Academy of Science, delivered his presidental address, "Scenes in Ohio During the Last Ice Age." Professor G. G. Acker, Executive Secretary of the Junior Division announced awards to outstanding high school teachers. At the business meeting officers were elected to serve for the coming year, as listed at the head of this annual report. History was also made for The Ohio Academy of Science in the announcement of the first Executive Secretary. This post will be filled by Mr. Kenneth B. Hobbs who is expected to assume his new duties on July 1. Thirty-seven members of the Academy were announced as newly elected Fellows. Their names and sectional affiliation follow:

B—Ovid A. Alderman
G—Jack Calvert
J—Willard Carmean
AB—Carl Cohen
A—John H. Cooper
A—John L. Crites
E—John G. Daunt
G—Jesse H. Day
A—Frank DeMarinis
J—G. Kenneth Dotson
J—Evan C. Dressel
C—Richard H. Durrell
A—N. S. Fechheimer
B—T. Richard Fisher
B—Robert M. Giesy
D—Gordon E. Green
A—John R. Harrison
G—Nelson W. Hovey
E—E. Leonard Jossem
G—Albertine Krohn
B—Robert W. Long
C—Milford S. Lougheed
E—Howard N. Maxwell
D—Jurgen R. Meyer-Arendt
I—Frank F. Miles
J—Henry R. Moore
C—H. Gray Multer
A—Theodore B. Myers
I—Samuel C. Newman
G—Harold G. Oddy
A—Glenn W. Peterjohn
J—Homer F. Price
G—Edward B. Rosser
C—George C. Shearrow
H—Irwin L. Slesnick
A—Arthur G. Steinberg
F—John L. Thompson

President Goldthwait presented Certificates of Appreciation to the Kroger Company, the Owens-Illinois Glass Company, and Dr. C. M. Goethe, a Distinguished Service Award to the Charles F. Kettering Foundation, and Ten-Year Membership Awards to O. M. Scott & Sons, Bonded Scale and Machine Company, Wittenberg College, Case Institute of Technology, Marietta College, Bowling Green State University, Miami University, Ohio University, University of Cincinnati, and Ohio Wesleyan University.

On Saturday the section of Physics and Astronomy held a joint meeting with the Ohio Section of the American Physical Society. The section of Geology held an all-day field trip, and the section of Physics and Astronomy sponsored a trip to the 2000 kilowatt reactor of the Battelle Memorial Institute.

Respectfully submitted,

George W. Burns, *Secretary*

REPORT OF THE EXECUTIVE COMMITTEE AND THE COUNCIL

The Executive Committee met October 11, 1958, December 5, 1958, January 24, 1959, March 28, 1959, and April 16, 1959; the Council met December 6, 1958 and April 16, 1959.

1. *Meetings of the Executive Committee.*—Much of the meeting time of this committee was taken up in formulation of application forms for the position of Executive Secretary, in screening more than sixty applications for that post, and in interviewing applicants for the position. As noted in the report of the annual meeting, Mr. Kenneth B. Hobbs is expected to assume his duties as Executive Secretary on July 1. In other actions, the committee approved a new seal for the Academy, authorized a new edition of the information brochure, confirmed the requirement of abstracts of papers at sectional meetings, authorized application to the National Science Foundation for a grant to assist with a special symposium in the section of Chemistry at the annual meeting, authorized acceptance of the invitation of the University of Toledo for the Academy to hold its 1962 meeting there, authorized a contract with The Ohio State University Press for publication of "Woody Plants of Ohio," accepted a grant of $15,000.00 from the Charles F. Kettering Foundation in support of the Executive Secretaryship project, and authorized three Certificates of Appreciation, a Distinguished Service Award, and ten Ten-Year Membership Awards.

2. *Meetings of the Council.*—Reports were presented by all officers and committee chairmen. Their annual reports are presented in the following pages.

Steps are being taken to secure a grant from the National Science Foundation to finance part II of "The Vascular Flora of Ohio," which will be "Monocots of Ohio," under the direction of the Academy's Ohio Flora Committee. President Goldthwait reported that letters had been sent to the Governor and to State Highway Department officials regarding the preservation of outdoor education and recreational areas, as urged by the section of Conservation. Replies, assuring the Academy that its concerns were being kept in mind, were received subsequently from both the Governor and the Director of Highways.

The report of the Committee on Training and Certification of Science Teachers is to be circulated to all members of the Council with a request for suggestions and criticisms. Council also authorized the chairman of the committee to draw up a proposal for a grant of funds to be used to speed and facilitate the work of this committee.

The next annual meeting was scheduled for April 21–23, 1960 at Antioch College, Yellow Springs.

Respectfully submitted,

GEORGE W. BURNS, *Secretary*

REPORT OF THE TREASURER

FISCAL YEAR 1958

ACADEMY BUSINESS

	1958	*1957*
RECEIPTS:		
Bank Balance, January 1	$ 3,443.15	$10,735.77
Membership Dues	4,281.00	4,160.00
Sale of Publications	22.52	6.14
U. S. Bonds interest	12.50	47.50
Modern Finance Co. interest	400.00	—
National Science Foundation Grant No. 2714	2,000.00	4,000.00
National Science Foundation Grant No. 5127	400.00	—
Gift—Pittsburgh Plate Glass Foundation	100.00	—
Gift—C. M. Goethe	100.00	50.00
Gift—C. F. Kettering Foundation	15,000.00	—
Junior Academy	1,392.60	1,022.00
Rental of exhibit space	25.00	—
Refund	—	10.00
From Research Fund, BancOhio Stock	—	22.00
	$27,176.77	$20,053.41
EXPENDITURES:		
Subscriptions and engraving, Ohio Journal of Science	$ 2,376.90	$ 3,068.54
Printing Annual Report	148.83	165.51
Printing Announcements and Notices	269.00	215.00
Public Relations	92.25	65.92
Postage, office supplies, bank charges, auditing and other administrative expense	971.32	1,049.05
National Science Foundation Grant No. 2714	2,672.83	2,675.93
National Science Foundation Grant No. 5127	386.07	—
Junior Academy	2,151.60	1,320.97
Academy Conference	23.00	11.50
BancOhio Stock	—	37.84
Modern Finance Company Investment Certificate	—	8,000.00
Bank Balance, December 31	18,084.97	3,443.15
	$27,176.77	$20,053.41
Excess Income over Expense	$14,641.82	$ 707.38

RESEARCH FUND

RECEIPTS:		
Bank Balance, January 1	$ 479.08	$ 448.79
Interest, Savings Account	128.49	83.17
U. S. Bonds Interest	5.00	5.00
BancOhio Dividends	50.00	44.60
Grant—A.A.A.S.	366.00	—
Bank Service Overcharge	—	3.69
	$ 1,028.57	$ 585.25
EXPENDITURES:		
Grants	$ 700.00	$ —
Bank Service Charges	—	1.00
Interest, still in Savings Account	128.49	83.17
BancOhio Stock, to Academy	—	22.00
Bank Balance, December 31	200.08	479.08
	$ 1,028.57	$ 585.25
Excess Income over Expense	—	30.29
Excess Expense over Income	$ 279.00	—

Respectfully submitted,

ELTON F. PADDOCK, *Treasurer*

REPORT OF THE ACADEMY LIBRARIAN

The Ohio Journal of Science, official publication of The Ohio Academy Science, has been used to initiate 27 new exchanges, with the Ohio State University Libraries being the recipient of 38 new titles. The new total of active exchanges would have increased from 543 to 570, but, due to several reasons, it was necessary to drop 14 institutions from the exchange list. The actual total of exchanges, as of April 10, 1959, is 556. Of the new exchanges, 22 are foreign, and 5 are domestic.

The Ohio Journal of Science is being sent to 423 foreign institutions and 133 United States institutions. The institutions dropped from the exchange list were 7 U. S. and 7 foreign institutions. Reasons for dropping the 14 institutions were, the exchange publications had been suspended, request received for exchange to be converted to a subscription, no response to claims for missing exchange materials, (a time limit of three months is given foreign institutions), and publications in the field of natural sciences no longer desired on exchange.

Revenue for the sale of the *Special Papers*, by the Gift and Exchange Division amounted to $6.67.

Respectfully submitted,

(Miss) Mary B. Pinson, *Librarian*

REPORT OF THE JOINT ADMINISTRATIVE BOARD OF THE OHIO JOURNAL OF SCIENCE

The annual meeting of the Joint Administrative Board of The Ohio Journal of Science was held at Columbus on April 4, 1959. The meeting was called to order by Board Chairman Hoel. Present were Mr. B. S. Meyer and Mr. Robert L. Bates representing The Ohio State University; Mr. C. E. Hoel representing The Ohio Academy of Science; and Mr. H. L. Plaine and Mr. R. A. Popham of The Ohio Journal of Science staff. Mr. Warren P. Spencer was unable to attend.

Minutes of the last meeting were approved as read.

Mr. Robert L. Bates was elected Chairman of the Board for the year 1959–60.

The report of the business manager was approved as read. This report, which accompanies these minutes, is mainly in the form of a financial statement for Volume 58. Mr. Popham reported that during the past summer the back issues of the Journal were carefully wrapped and arranged in chronological order on steel shelving in one location in the main Ohio State University Library. He also reported that (1) the bank balance is substantially the same as that of a year ago; (2) circulation of the Journal increased to about 1925 during the year; (3) the basic charge for printing Volume 59 of the Journal will be about $200.00 greater than for Volume 58; (4) postage charges will be about $60.00 greater for Volume 59; (5) there will be an estimated deficit of about $600.00 for Volume 59, exclusive of gifts.

The report of the editor, Mr. Plaine, was approved as read. A copy of this report is attached to these minutes. The editor indicated that the Journal is about six months behind in publication of papers. This time delay in publication of papers is considered to be about minimum.

The following staff members were re-elected for the year 1959–60: Mr. Plaine, Editor; Mr. Popham, Business Manager; and Mr. T. H. Langlois, Book Review Editor.

The Board commended the Editor and Business Manager for their efforts in implementing the change to a new and more attractive cover which first appeared on the January, 1959 issue of the Journal.

After a short discussion, the Board agreed unanimously that the Journal should no longer continue to depend upon gifts in order to balance its budget. Mr. Popham was instructed to write a letter to the President of The Ohio State University requesting the sum of $3,000.00 from the University in payment of subscriptions which the library will use as a basis for exchanges with other scientific organizations and publications during the fiscal year 1959–60.

The sum of $3,000.00 annually represents an increase of $500.00 over the rate of payment which the University has made to the Journal since 1953 when costs of publication were considerably lower than at the present time. In recommending this increase, the Board was mindful of the fact that income from The Ohio Academy of Science subscriptions is likely to increase during the year 1959.

There being no further business, the Board adjourned.

Respectfully submitted,

Richard A. Popham, *Secretary of the Board*

THE OHIO JOURNAL OF SCIENCE

Balance Sheet

	Vol. 57 Fiscal Year 1/1/57 12/31/57	Vol. 58 Fiscal Year 1/1/58 12/31/58
Receipts:		
Bank balance at beginning of period	$ 2,751.32	$ 2,974.19
O.S.U.—paid for subscriptions	2,500.00	2,500.00
O.A.S.—paid for subscriptions	2,009.00	2,044.50
Non-members—paid for subscriptions	663.90	599.00
Separate numbers, volumes and reprints sold	210.75	656.99
50 year index sold	20.00	20.00
O.A.S.—paid ½ cost of plates	259.54	332.40
O.A.S.—paid for annual report	165.51	148.83
Miscellaneous	67.53	132.55
Advertisements	447.18	383.94
Charles F. Kettering—Gift	800.00	0.00
	$ 9,894.73	$ 9,792.40
Expenditures:		
Spahr and Glenn—printing O.J.S.	$ 5,482.91	$ 5,628.44
Bucher Engraving—plates	664.80	455.99
Postage and express	240.74	239.91
Labor	52.50	53.00
Office expenses and bank charges	145.69	84.00
Advertising of the O.J.S.	10.00	50.00
Reprints	0.00	26.93
Mailing envelopes	255.37	0.00
Refunds	1.00	10.50
Miscellaneous	67.53	13.55
Bank balance at end of period	2,974.19	3,230.08
	$ 9,894.73	$ 9,792.40

THE OHIO JOURNAL OF SCIENCE

Report of the Editor of Volume 58, 1958, to the Joint Administrative Board

Volume 58 of The Ohio Journal of Science contained 412 pages (4 pages more than volume 57), of which 363 pages were devoted to 53 scientific papers in 9 areas of science (as designated by sections of The Ohio Academy of Science); 13 pages were devoted to affairs of the Academy 10 pages to advertising; and 26 pages to announcements, book notices, index, table of contents, and routine journal copy. Thirty-six book notices were published. Publication of papers by fields is presented in the folllowing table.

By making greater demands upon the authors with respect to terseness and clarity, and by modifying somewhat our format for planning each issue, we have been able to increase the number of papers published in volume 58 over those published in each of the three previous volumes without substantially increasing the number of pages devoted to them. We wish to thank the various members of the Academy, as well as our many colleagues outside the state, who have so generously reviewed manuscripts or acted as referees.

Respectfully submitted,

Henry L. Plaine, *Editor-in-Chief*

Distribution by Field of Articles Published in 1958

Field	No. of articles	Total pages	Percent
Anthropology and Sociology	4	27	7.4
Chemistry	8	35	9.7
Conservation	1	12	3.3
Geography	1	8	2.2
Geology	6	62	17.1
Plant Sciences	9	61	16.8
Science Education	2	15	4.1
Zoology	21	136	37.5
Genetics	1	7	1.9
Total Scientific Papers	53	363	100.0

REPORT OF THE DIRECTOR OF PUBLIC RELATIONS

This year eight news releases were or are being sent out during the period preceding and accompanying the annual meeting. Coverage was somewhat better than last year, though again not much material was provided outside of the actual program of the annual meeting. No person in the Academy provided any information for news releases during the year, except in connection with the District Science Days. Again, without a clipping service (or the cooperation of members of the Academy) we have no way of judging the effectiveness of the releases.

It was hoped that all abstracts and some entire papers would be ready for distribution at least a week prior to the annual meeting, but inasmuch as only half the Section Vice-Presidents submitted abstracts in advance this has not been possible. Those submitted are being made available during the meeting.

A budget of $125.00 was provided for Public Relations this year. Recently the Executive Committee authorized up to another $50.00. Total expenditures for the year as follows:

Postage	$ 67.30
Stencils	21.50
Typing	62.50
Total	$151.30

Plans for next year will, of course, depend on the action of the new Executive Secretary. In general, it is anticipated that the position of Director of Public Relations will become an advisory one.

Respectfully submitted,

JOHN R. COASH, *Director*

REPORT OF THE EXECUTIVE SECRETARY OF THE JUNIOR DIVISION, OHIO ACADEMY OF SCIENCE

The eleventh year of Junior Division operations was devoted primarily to the expansion of the Science Day Program in order to keep pace with increased interest throughout the State. Emphasis was placed upon encouraging local science days for the purpose of choosing participants at District Science Days. The number of projects permitted at State Science Day was limited for the first time in our history. The first brochure of the Junior Division was printed in January. Activities prescribed by the Constitution (District Science Day, State Science Day, Ohio Academy of Science News, Scholarship Tests, Teacher Awards and Special awards) took place in a normal manner with several improvements. The State Science Day Award will be presented for the first time at the 1959 State Science Day.

SECTION I ORGANIZATION

The only change in district and state organization was the establishment of a State Science Day Award Committee to administer the new award.

SECTION II DISTRICT SCIENCE DAYS

Approximately 6000 students in 7th through 12th grades exhibited projects at the eight district science days. More than 500 schools were represented at these district science days which were visited by over 11,000 persons. For the second consecutive year, Central District restricted participation to 5% of each school's enrollment in science courses. The most difficult problem faced by District Councils during the present year was that of selecting entries for State Science Day. Several plans for this selection were operative including judging by points systems and special judging of the outstanding projects. A brief summary of the 1959 District Science Day Program follows:

		Projects	Individuals
March 22	—Central, Ohio State University	790	790
	—East, Muskingum College	263	287
	—West, Wittenberg University	475	588
	—Southwest, Miami University	515	647
April 4	—Northeast, Kent State University	747	799
	—Northwest, Bowling Green State University	1353	1552
	—North Central, Heidelberg	700*	800*
	—Southeast, Ohio University	300*	350*

*Estimate

A complete analysis of District Science Day participation is included as an annex to this report.

SECTION III STATE SCIENCE DAY

The number of projects to be entered at the 1959 State Science Day is limited to 600. The total number was based upon space and facilities available at Capital University and upon the number of judges available.

Based upon participation at the 1958 State Science Day, each district was allocated spaces at this year's State Science Day as follows: Southeast 24; East 36; Northeast 75; North Cen-

tral 72; Central 144; Southwest 50; West 62; and Northwest 138. Since about 75 of these are joint projects the total number of participants will be nearly 700 representing 213 schools. Sectional meetings will be suspended at 11:00 AM for judging of projects.

Section IV Ohio Academy of Science News

"The Ohio Academy of Science News" replaced "Newsletter" as the name of newspaper published by the Junior Division. Mrs. Clara Kinney of Chillicothe served as editor for the three numbers published this year. Circulation increased from 5000 to 5500 copies per issue.

Section V Scholarship Tests

Capital University testing service will conduct the scholarship tests this year. Mr. Sylvan Mikelson, University School, Ohio State University, is chairman of the scholarship committee.

Section VI Teacher Awards

This year recipients of the Outstanding Teacher Award will be permitted to choose membership in one of a dozen different scientific societies in addition to AAAS.

The 1959 Outstanding Teacher Award winners are:

Northeast	—Betty Olmstead, Northfield High School
East	—John V. Pergi, Steubenville High School
Southeast	—Robert Harrison, Jackson High School
North Central	—Mrs. E. C. (Thelma) D'Almaine, Danbury Township
Central	—Sister Rosarii, Bishop Watterson
Southwest	—Harold Shaw, West Alexandria High School
West	—Mr. L. L. Brinkley, Blume High School, Wapakoneta
Northwest	—Ralph Benard, Lake Township High School

VII School Awards

A. The Kroger Company will present eight awards again this year. The cash portion of these awards has been reduced to $25 in 1959. Mr. Irwin Slesnick, chairman of the Special Awards Committee announces the following winners for 1958:

Northwest	—Archbold High School, Archbold
North Central	—Avon Lake High School, Avon Lake
Northeast	—Mogadore High School, Mogadore
West	—Jackson Local School, (Darke County) Union City, Indiana
Central	—Bishop Watterson High School, Steubenville
East	—Steubenville High School, Steubenville
Southwest	—Purcell High School, Cincinnati
Southeast	—Fort Frye Local School, Beverly

B. State Science Day Award. This award consists of a bronze plaque and will be awarded on the basis of participation at State Science Day. The plaque is engraved as follows:

OHIO ACADEMY OF SCIENCE
STATE SCIENCE DAY
AWARD
19—

All schools meeting the following criteria will be awarded a plaque:

(1) A minimum of 5 projects at State Science Day
(2) No individual rating less than Excellent.
(3) 85% of all participants rated "Superior".

Thirty one schools have five or more projects entered this year.

Section VIII Extension

Thirty nine school organizations have affiliated with the Junior Division for the purpose of conducting local science days. Sixteen schools report a total of nearly 36,000 visitors viewed the exhibits of more than 6300 students. Morrow County Science Week had 885 participants.

The following affiliated Science Days are listed by district.

Northeast	—Canton City; Medina.
East	—Bishop Rosecrans, Zanesville; Scio
Southeast	—Chillicothe; Logan.
North Central	—Jackson Junior High, Sandusky; Morrow County; Ottawa County; Sandusky County; Erie-Huron County; Galion; Elyria; Lexington; St. Mary, Sandusky; Avon Lake; Marion Catholic; Mansfield Secondary; Clyde; Marion.
Central	—Bishop Watterson; St. Mary of the Springs; Licking County; Westerville; New Albany; St. Mary, Columbus; Lancaster.
Northwest	—Perrysburg; Liberty Center; Fostoria; Great Northern Science Association; Lake Township; North Baltimore; Defiance.

West —Fairborn; Fort Loramie; Champaign County.
Southwest —Kettering, Fairmont; Germantown.

Section IX Brochure

The first brochure for the Junior Division was printed in January. It is an eight page illustrated brochure printed in brown. Copies have been distributed to all mailing lists of the Academy.

Section X Changes and Regulations

Regulations were changed to permit affiliation of local science days with the Academy and to establish associate memberships for participants at these local exhibits.

Section XI Personnel

Changes in personnel in the Junior Division Council have been made as follows:

Councilmen:
Southeast —Dr. James T. Shipman, Ohio University
—Ralph R. Walker, Logan High School
East —Rudolph Gerlach, Muskingum College
Northeast —Robert E. Stevens, Lincoln High School, Canton
Northwest—Richard S. Phillips, Findlay High School
Southwest—Dr. Floyd James, Miami University
—Harold Shaw, West Alexandria High School
Central —Joseph A. Ralston, Westerville High School
Editor Ohio Academy of Science News—Mrs. Clara Kenney
Committee chairmen—Scholarship, Sylvan Mikelson, University School, Ohio State University
—State Science Day Awards, Charles Hoel, Columbus

Section XII Miscellaneous

Owens-Illinois Glass Company of Toledo donated 700 sets of souvenir glasses for distribution to science day participants.

Dr. Arthur L. Lutz is chairman of the committee studying ways of controlling entries at State Science Day.

The large number of participants at the district science days indicates the necessity of continued action to establish new districts and/or to encourage elimination by affiliated local science days.

A major problem facing the Junior Division involves coordination of the many science exhibits throughout the state.

Respectfully submitted,
Gerald Acker, *Executive Secretary*

REPORT OF THE TRUSTEES OF RESEARCH FUNDS
for the Period of April, 1958 to April, 1959

During this interval the Trustees received four requests for grants in aid for graduate student research. All of these requests were honored as follows:

Mr. Wesley R. Tinker, III, Department of Geology, Ohio State University; aid for travel expense in compiling data for Master's thesis $60.00

Mr. Thomas D. Erickson, Department of Geology, Ohio State University; aid for travel expense in compiling data for Master's thesis $60.00

Mr. Irwin H. Kantrowitz, Department of Geology, Ohio State University; aid for travel expense in compiling data for Master's thesis $60.00

Mr. Weston Blake, Jr., Department of Geology, Ohio State University; for purchase of 134 Norwegian air photos of a part of North-East Land, Spitsbergen, the field area where data were obtained in glacial geology and geomorphology, for his doctorate dissertation. . $95.00

Total of the four grants made $275.00

This leaves at present a balance of $349.00 available from the A.A.A.S.

No requests for grants were received from the Junior Academy.

Respectfully submitted,
Glenn W. Blaydes, *Chairman*

REPORT OF OHIO FLORA COMMITTEE

Manuscript of "Woody Plants of Ohio" has been accepted for publication by The Ohio State University Press as soon as completed. This will be *Part I* of *Vascular Flora of Ohio*. It is planned that the final manuscript will be completed by June 1959.

The Flora Committee, at a special meeting November 4, 1958, approved a proposal to be sent to the National Science Foundation for work on *Part II* of the *Vascular Flora of Ohio, The Monocotyledons*. The committee has named E. Lucy Braun as chief investigator of this project.

Work is continuing on other parts of the Flora. Following the preliminary work on the Compositae by Robert W. Long Jr., critical checking of herbarium material of the family is in progress. This portion of the study follows the preliminary list of species which appeared in the spring of 1957.

Three additional investigators will begin participation in the preparation of the Flora. They are Tom Cooperrider, William Easterly, and Donald Dean, all taxonomists in the state of Ohio.

Respectfully submitted,

T. Richard Fisher, *Chairman*

REPORT OF THE ACADEMY HISTORIAN

The Academy Historian is continuing a series of reports on the history of The Ohio Academy of Science and its various sections. At the Akron meeting in 1958 the series was initiated with reports given to the Section of Zoology and the Section of Plant Sciences. This year similar accounts will be presented to the Section of Geology and the Section of Medical Sciences. Additional ones are planned for the future in chronological order.

A bibliography pertaining to the history of The Ohio Academy of Science has been compiled and is herewith presented.

Academy Secretaries. 1892. The Ohio State Academy of Science. Constitution, by-laws, officers, list of members, and historical sketch. (Historical sketch by W. R. Lazenby). Published by authority of the executive committee (Columbus, Ohio).

1893–1903. Annual Report (1–11) of the Ohio State Academy of Science. Published by the Academy.

1904–1912. Proceedings of the Ohio State Academy of Science. Annual Report (12–21) Vol. 4 (parts 1, 5, 7, 9); Vol. 5 (parts 1, 4, 6, 8); Vol. 6 (part 1). Published by the Academy.

1913–1930. Proceedings of the Ohio Academy of Science. Annual Report (22–40). Vol. 6 (parts 2–5); Vol. 7 (parts 1–10); Vol. 8 (parts 1, 2, 4, 6, 7). Published by the Academy.

1931 1958. Annual Report of The Ohio Academy of Science (41–58). Ohio Jour. Sci. July issue (no. 4) of Vol. 31–40, 42–43, 49–58; Nov. issue (no. 6) of Vol. 41; Sept. issue (no. 5) of Vol. 44–48.

1916. Annual Report of The Ohio Academy of Science. Twenty-fifth meeting—quarter centennial anniversary—1915. Proceed. Ohio Acad. Sci. 6(5): 205–406.

1931. Past officers, committeemen, places of annual meeting: 1892–1931. Ohio Academy of Science. Ohio Jour. Science. 31(4): 196–198.

1892–1958. Programs, Annual Meeting of The Ohio Academy of Science. 1892–1958. (A nearly complete set is on file with the Academy historian).

Anon. 1914. List of members and constitution and by-laws of The Ohio Academy of Science. 20 pp. Published by publication committee of the Academy (Columbus, Ohio).

1934. Concerning the journal. Ohio Jour. of Sci. 34: 65–66.

Alexander, W. H. 1941. The Ohio Academy of Science (Mostly historical). Ohio Jour. Sci. 41(4): 287–311. (Fiftieth Anniversary celebration—includes portraits of all charter members assembled and arranged by E. M. Miller).

Blaydes, G. W. 1951. A brief history of the Ohio Journal of Science. Ohio Jour. Sci. 51(4): 205–206.

Dexter, R. W. 1958. Report of the academy historian. Ohio Jour. Sci. 58(4): 259–260.

Krecker, F. H. 1950. The Ohio Junior Academy of Science. Ohio Jour. Sci. 50(6): 301 304.

Lampe, Lois. 1950. The origin and development of the Ohio State University with special reference to the biological sciences. Ohio Jour. Sci. 50(5): 201–204.

Lazenby, W. R. 1915. Historical sketch of The Ohio Academy of Science. Proceed. Ohio Acad. Sci. 6(5): 277–283.

Mendenhall, T. C. 1915. The relation of the academy to the state and to the people of the state. Proceed. Ohio Acad. Sci. 6(5): 284–298.

1920. History of the Ohio State University. Vol. 1. Ohio State Univ. Press, Columbus.

Miller, Ethel M. 1931. The publications and exchanges of The Ohio Academy of Science. Ohio Jour. Sci. 31: 224–226.

1953. General Index, 1900 1950. The Ohio Journal of Science (pp. 32 33; 73–74 for historical references).

O'Neal, C. E. 1939. Presidential address: Taking inventory. Ohio Jour. Sci. 39: 213 219.

Osborn, H. 1944. The research fund of The Ohio Academy of Science. Ohio Jour. Sci. 44(5): 213–218.

Rice, E. L. 1916. Ohio Academy of Science quarter-centennial anniversary. Ohio Jour. Sci. 16: 109–112.

Schaffner, J. H. 1902. Historical sketch. Tenth Annual Rept. Ohio State Acad. Sci. p. 11.

Various authors. 1941. Invitational addresses at the fiftieth anniversary celebration of the Ohio Acad. Sci. Ohio Jour. Sci. 41: 103–286.

Webster, F. M. 1900. Future work of the Academy of Science in Ohio. Eighth Annual Rept., Ohio State Acad. Sci. pp. 16–17.

Respectfully submitted,

Ralph W. Dexter, *Chairman*

REPORT OF THE RESOLUTIONS COMMITTEE

Be it resolved that the members of The Ohio Academy of Science express to the Administration of Capital University, to Dr. Robert M. Geist, chairman of the local committee on arrangements, and to the several members of his committee, their appreciation of the excellent facilities and thoughtful hospitality which have contributed greatly to the success of this, the 68th meeting of the Academy.

Respectfully submitted,

RALPH V. BANGHAM, *Chairman*

REPORT OF THE NECROLOGY COMMITTEE

In alphabetical order is a listing of the deaths that occurred in the membership of The Ohio Academy of Science in the interval between the annual meetings of April, 1958 and April, 1959.

1—**Mr. Arthur R. Harper,** Fellow of the Academy in the Conservation Section, field naturalist for the Ohio Division of Conservation and Natural Resources and a nature columnist for the Columbus Dispatch. Mr. Harper was born at Plain City, Ohio on Jan. 6, 1883. For a time he was a student at the Indiana State Normal School but did not complete the course to become a teacher.

In his earlier life he was an auditor for the Ohio State Life Insurance Company until 1939 when he became a Field Naturalist for the State of Ohio. He retired in 1953.

On July 17, 1929 he married a widow, Mrs. Ethel McHenry, by whom he had two daughters, Mrs. R. O. Blackwood and Mrs. James Meagher, and reared two step-children, Mrs. Wilson Foley and Bush McHenry. During his life he received citations for his booklets on wild life used in Ohio Schools and two books *Ohio In the Making* on the historical geology of the State and *Birds of Ohio.* He was a member of the Wheaton Club and the Audubon Society.

Mr. Harper died in Columbus on Jan. 1, 1959 of a cerebral hemorrhage in his 75th year and was interred in Dublin Cemetery, Dublin, Ohio.

2—**Dr. Normand Louis Hoerr,** a Fellow of the Ohio Academy in the Medical Section and Head of the Department of Anatomy in the Medical School of Western Reserve University. He was born May 3, 1902 in Peoria, Illinois, and was graduated from Johns Hopkins University with the Bachelor of Arts degree in 1923, received the Ph. D. from the University of Chicago in 1929 and the M.D. degree from the same institution in 1931. Dr. Hoerr held teaching positions of Assistant, Instructor, and Assistant Professor at Chicago from 1925 to 1939, when he accepted the position of Henry Wilson Payne Professor of Anatomy and Director of the Department of Anatomy in the Medical School at Western Reserve University until his death in 1958.

On Sept. 10, 1927 Dr. Hoerr married Miss Virginia Gale. There were no children.

Dr. Hoerr was the President-elect of the American Association of Anatomists at his demise and a member of the A.A.A.S., Sigma Xi, Alpha Omega Alpha, Phi Beta Pi, Society for Experimental Biology and Medicine, Cleveland Academy of Medicine, Director of the Cleveland Medical Library and Coeditor of Blakiston-Gould's Medical Dictionary. In the bibliography of his many books and scientific articles are 29 titles in the fields of anatomy, cytology and histology.

Dr. Hoerr died of carcinoma in his 56th year in Cleveland on Dec. 14, 1958 and was buried in Baltimore, Maryland.

3—**Dr. George D. Hubbard** was a Fellow of the Geology Section and Emeritus Head of the Department of Geology and Geography at Oberlin College. He was born at Tolono, Illinois on May 12, 1871 and secured his Bachelor of Science degree at the University of Illinois in 1896, and a Master of Science degree from the same institution in 1898. In 1901 he received his M.A. degree from Harvard University and the Ph. D. degree from Cornell University in 1905. His first academic position was Instructor of Geography at Cornell from 1904–1905. Next he served as Assistant Professor of Geology at Ohio State University from 1905 to 1910 where he was also Secretary of the College of Education from 1907 to 1910. In 1910 he went to Oberlin College as Professor of Geology and Geography and remained until 1936 after which he was on Emertus rank at Oberlin. During these years he also was Assistant Geologist for the Ohio Geological Survey. After retirement at Oberlin he was Visiting Professor of Geology at Berea, Kentucky in 1941 and at Missouri State University from 1942 to 1948. He was a Fellow of the American Geographical Society and also of the Geological Society of America. He was President of The Ohio Academy of Science in 1915.

On September 10, 1901 Dr. Hubbard was married to Miss Edna Rugg who survives him as also the daughters, Ruth Marcilla, Dorothy Hope, Marjorie Helen and one son, Oscar Edwin Hubbard.

Dr. Hubbard published numerous papers on geology and geography and is the author of a text-book *The Geography of Europe.* On June 11, 1958 he died in his 87th year of uremia and was buried in Westwood Cemetery, Oberlin, Ohio.

4—**Dr. Charles Franklin Kettering,** Fellow of the Academy in the Physics and Astronomy Section, was nationally known for his many inventions in the field of engineering as well as Director of Research for the General Motors Corporation.

Dr. Kettering was born in Loudonville, Ohio on Aug. 29, 1876. He graduated from Ohio State University in 1904 as an Electrical and Mechanical Engineer. Later in his life more than 40 Colleges and Universities gave him honorary degrees. From about 1915 he was Director of Research for General Motors Corporation until 1947 when he retired to a consultant status. For many years he was consulting engineer for the National Cash Register Corporation in Dayton. In 1920 he organized the Dayton Engineering Laboratory to work upon his own inventions such as the rural home lighting systems, starting and ignition systems for automobiles, etc. He was also an organizer of the Dayton Metal Products Co. In 1927 he financed the Kettering Foundation at Yellow Springs, Ohio to carry on research in diverse projects such as chlorophyll and photosynthesis. At different periods he was President of the Edison Foundation and the Sloan-Kettering Foundation for Cancer Research. He was also a trustee of Ohio State University and many other colleges. He was Chairman of the National Inventors' Council and promoter of numerous studies on higher octane fuels, tetra-ethyl lead and non-toxic refrigerants.

On August 1, 1905 Dr. Kettering married Miss Olive Williams who preceded her husband in death in 1946. To this union was born one son, Eugene Williams Kettering.

Dr. Kettering died of arteriosclerosis in his 82nd year at Dayton, Ohio on Nov. 25, 1958 and was buried at Dayton where he had lived for many of his fruitful years.

5—**John A. Michael,** member of the Academy in the Science Education Section and identified for years with the public school system of Eaton, Ohio. Mr. Michael was born on Sept. 15, 1891 at Eaton, Ohio and secured his Bachelor of Arts degree in Adelbert College of Western Reserve University in 1922. Later he received a master's degree in Education at Ohio State University and a Bachelor of Science in Chemical Engineering from Tri-State College.

From 1930 to 1937 Mr. Michael was Superintendent of Schools of Eaton, Ohio and from the latter year until his death was a science teacher in Eaton High School. In 1953 he was named the outstanding science teacher of the year in Ohio public schools. He was one of the organizers of Science Day at Miami University.

On June 8, 1930 Mr. Michael married Miss Margaret Allen; to them were born four children: James Allen Michael, Mary Anna Michael, Thomas Arthur Michael and George Edward Michael.

On Oct. 7, 1957 Mr. Michael succumbed to carcinoma of the lung and was interred in Mound Hill Cemetery in Eaton, Ohio.

6—**Ferris W. Myrice,** a member of the Academy in the Science Education section was for 28 years a science teacher in the Bowling Green Junior High School. He was also a promoter of the Junior Academy of Science in Northwest Ohio.

Mr. Myrice was born in Deshler, Ohio on May 7, 1896. He received his Bachelor of Arts degree at Defiance College about 1915 and the Master's degree from Ohio State University about 1925. During World War I he served his country in the 332nd Infantry Reg. U.S.A. Before his military service he taught a rural school in Henry County, Ohio during 1914 and 1915. From 1919 to 1925 he was a principal and mathematics and science teacher in Deshler Schools. From 1926 to 1929 he was principal at Harrod High School and in the latter year came to Bowling Green Junior High School as a mathematics teacher. In 1936 he became its science teacher and held the position until his death. In 1955 he was voted the outstanding science teacher in Northwest Ohio.

On July 31, 1921 Mr. Myrice married Miss Janette Loach of Lima and to them were born two daughters, Miss Josephine Myrice, RN and Mary Jane Myrice in Bowling Green who with their mother survive him.

Mr. Myrice was active in public service in Bowling Green and served as First Aid Chairman for the Wood County Red Cross and for 45 years was a worker in Boy Scout activities—achieving the Silver Beaver award.

From 1945 to 1954 during the summers Mr. Myrice was employed as a technician of the Ohio Experiment Station and in a project sponsored by H. J. Heinz Co. developed by his research a new variety of cucumber. He also is coauthor of three publications of the Ohio Experiment Station on various types of beans. He was a member of the Bowling Green Masonic lodge and the Presbyterian Church.

On Feb. 7, 1957 Mr. Myrice died in Wood County Hospital, aged 60 years, of lymphosarcoma and was interred in Oak Grove Cemetery at Bowling Green.

7—**Miss Helen Lucille Park,** member of the Academy in the Zoology Section and for ten years Assistant Professor of Biology at Akron University. Miss Park was born on Feb. 24, 1898 at Scottsville, Kansas and secured her Bachelor of Arts degree at Ottawa University in 1920 and the Master of Arts degree at the University of Nebraska in 1923. Over the years she did additional graduate work at Iowa University, Puget Sound Biological Station, Friday Harbour, Washington; and the Universities of Colorado and Kansas.

She held academic positions in biology at these institutions; El Paso (Tex.) High School and El Paso Junior College, Tabor College, Tabor, Ia. and for a while was instructor in English at an Aircraft Technical School in Sao Paulo, Brazil and finally as Ass't. Prof. of Biology at Akron University from 1947 to 1957.

Miss Park was a member of the Society of the Sigma Xi and the author of various papers on anatomy - the most recent being "The Heart and its Vessels in Some New World Bats" in 1954 published in the Transactions of the Kansas Academy of Science.

In September, 1958 Miss Park died at Laurence, Kansas of carcinoma in her 61st year and was buried at Neodesha, Kansas.

8—**Dr. Daniel P. Quiring,** a Fellow of the Academy in the Medical Section was Associate Professor of biology at Western Reserve University, Cleveland and Head of the Bunts Educational Institute, an affiliate of the Cleveland Clinic Foundation.

Dr. Quiring was born on Oct. 22, 1894 at Newton, Kansas and received his AB degree from Oberlin College in 1917, his M.A. from the University of Illinois in 1928 and the Ph. D. degree from Western Reserve University in 1932. He was an Assistant in Zoology at the University of Illinois from 1927 to 1929 and in that year came to Western Reserve University as an Instructor. In 1933 he was promoted to the rank of Assistant Professor and in 1945 to Associate Professor. From 1934 until his death he was also Head of the Bunts Educational Institute.

He was a member of the A.A.A.S., the American Society of Zoologists, the American Association of Antomists, the American Society of Physical Anthropologists and Sigma Xi. In World War I he was surgical assistant in the AEF in France. He also belonged to the American Museum of Natural History, the Cleveland Museum of Natural History and was on the Board of Governors of the Cleveland Zoological Society.

Dr. Quiring was a pioneer in the use of films in teaching anatomy and many of his films are used throughout the country. He published more than 30 papers in the fields of anatomy, morphology and relative growth—and was the author of these medical text-books: "Head, Neck and Trunk"—Lea & Febiger, "The Extremities"—Lea & Febiger and "Collateral Circulation"—Lea & Febiger and a college text, "Functional Anatomy of Vertebrates"—McGraw Hill.

Mrs. Quiring, nee Marion Haggerty, died in July 1957. There survive two daughters, Mrs. Clemens von Koschembahr and Mrs. Ann Shure.

On March 25, 1958 Dr. Quiring died in Cleveland of acute leukemia at the age of 63 years and was buried in Lakeview Cemetery, Cleveland.

9—**Professor Emmett Rowles,** Fellow of the Academy in the Zoology Section was Associate Professor of Physiology and Biochemistry at Ohio University, Athens, Ohio where he had served on the faculty for 38 years in various capacities.

Professor Rowles was born at New Metamoras, Ohio on Nov. 9, 1899 the son of a physician there. After graduation from the local high school he and his twin brother, Everett Rowles, came to Ohio University, where he received the A.B. degree in 1920. He secured his M.A. degree from the University of Minnesota in 1923. He did graduate research work in 1921 and 1924 at the University of Washington's Marine Biological Station and during four different summers at the University of Minnesota. He spent that of 1933 at the Stone Laboratory of Ohio State University.

His academic career started in 1918 as Assistant in Spanish at Ohio University and in biology in 1920 and also served as an Assistant in Zoology at Minnesota in 1920–1923 and in Physiology in 1923. He returned to Ohio University in 1923 and after service as Assistant Professor became finally Associate Professor of Physiology in 1933. Professor Rowles was a member of several scientific societies in zoology and psychology and was elected to the honor societies of Phi Beta Kappa, Sigma Xi, Gamma Alpha and the Torch Club. He was member of Theta Chi Fraternity. He published articles in the Journal of Experimental Zoology and the Journal of Applied Psychology.

On June 4, 1921 Professor Rowles married Miss Jessie M. Hostetter; to them were born three daughters: Mrs. Jessie Marie Tom, Mrs. Elsie Lou Bobo and Mrs. Cornelia Ann Ruth. He is survived by them, his wife and 9 grand-children.

On Nov. 8, 1958 he suffered a severe cerebral hemorrhage and died suddenly one day prior to his 59th birthday. He was buried in West Union St. Cemetery in Athens, Ohio.

10—**Dr. William H. Shideler,** Fellow of the Academy in the Geology Section, was Professor and Chairman of the Department of Geology at Miami University for many years and for the last two years, Professor of Geology at Hiram College. He was born on July 14, 1886 at West Middletown, Ohio. He received his A.B. at Miami University in 1907 and the Ph. D. degree from Cornell University in 1910. In the same year he started his career at his alma mater as Assistant Professor of Geology and Zoology and later Associate Professor and finally in 1920 was appointed Professor and Head of the Department of Geology, becoming emeritus in 1957. During the years 1957 and 1958 he was Professor of Geology at Hiram College.

On June 16, 1911 he married Miss Katherine Hoffman. They had two sons, William W. and James H. Shideler. Dr. Shideler was a Fellow of the A.A.A.S., and a member of the Geological Society of America, Phi Beta Kappa, Sigma Xi, Phi Sigma, Sigma Gamma Epsilon, Omicron Delta Kappa and a founder of Phi Kappa Tau. He was President of The Ohio Academy of Science in 1951.

In December, 1958 Dr. Shideler died at the age of 72 years as the result of a cerebral hemorrhage. He was interred at Oxford, Ohio where he had lived as student and professor for so many years.

11—**Mrs. Stanley D. Simon** (nee Cecile Freiberg), a member of the Academy in the Plant Sciences Section and former graduate student at the University of Cincinnati.

Mrs. Simon was born on April 13, 1908 in Cincinnati, Ohio and attended Smith College where she received the B.A. degree in 1930.

In 1933 Cecile Freiberg married Dr. Stanley B. Simon, a physician in Cincinnati. As a house-wife she continued her interest in plant science and enrolled as a graduate student at Cincinnati University. She attained the Master of Science degree in 1956 and was elected a member of the Cincinnati Chapter of the Society of Sigma Xi.

Mrs. Simon was the mother of two children, Jill S. Freeword and Margot Simon, who, with her husband, survive her.

On Jan. 29, 1958 Mrs. Simon died of adeno-carcinoma in her 50th year and was cremated in Cincinnati.

12—**Dr. Joseph Fisher Stanfield,** was a Fellow of the Academy in the Plant Sciences Section and Professor and Chairman of the Department of Botany at Miami University.

He was born on June 4, 1901 at Lewisburg, Kentucky and secured the A.B. degree at Western State College, Colorado, in 1927. In 1930 he received his M.A. degree at the University of Colorado and the Ph. D. degree from the University of Iowa in 1937.

He taught in several high-schools of the State of Colorado from 1927 to 1929. Then from 1931, through all but two years, until 1938, he was Assistant Professor of Biology at Knox College. From 1939 to 1943 he served as Professor of Botany at Chicago Teachers College and in his final position as Professor of Botany and Department Head at Miami University from 1944 until 1958.

On Aug. 1st, 1939 Dr. Stanfield married Miss Margaret Ellen Cox. There were no children.

Dr. Stanfield was a Fellow of the A.A.A.S., Botanical Society of America, the Illinois and Ohio Academies of Science, the Amer. Ass'n. of Biology Teachers, Amer. Forestry Ass'n. as well as Secretary-Treasurer of the Amer. Society of Plant Physiologists, the Amer. Ass'n. of University Professors, Society of Sigma Xi and Gamma Alpha. He was the author of numerous articles on reproduction of plants and methods of teaching biology in various biological journals.

In May, 1958 Dr. Stanfield died of a cerebral hemorrhage in his 57th year and was buried at Vermont, Illinois.

Analysis of this necrology report shows that 6 members died of cardio-vascular-renal syndrome, 5 died of cancer and one of leukemia. In this group of 12 deaths, 4 were 70 years or over while 8 were in the 5th and 6th decades of their lives.

H. H. M. Bowman, *Chairman*

Economics of Atomic Energy. *Mary Goldring.* Philosophic Library Inc., New York. 1957. ii+179 pp. $6.00.

This book was written for a popular, and primarily a British, audience. Its principal purpose seems to be that of evaluating the range of politico-economic influences of the British atomic energy program. The author's technique is impressionistic, indeed, probably too much so for even a popular account, with emphasis being placed on personalities and external appearances.

The opening and closing chapters are almost unconsciously hung on a loose travelogue of British atomic energy installations. A light, surprisingly inaccurate description of atomic technologies is included. The most serious part of the book is found in three central chapters on atomic power for British home consumption and overseas trading interests.

Miss Goldring's broad general comments on the role of atomic energy in underdeveloped countries and on the export market for British atomic products are germane and significant, though incomplete. Where closer economic analysis is required in the specific case of atomic power for Britain, her discussion falls short of an adequate treatment.

Richard A. Tybout

Concise International Dictionary of Mechanics and Geology. *S. A. Cooper.* Philosophical Library Inc., New York. 1958. viii+400 pp. $6.00.

Nearly six thousand terms are rendered in English, French, German and Spanish in this compact volume. The dictionary is arranged in English, with the equivalent terms appearing in the order named. A complete index of all the terms is given for each of the three other languages. The suite of terms described in this book is designed to be of service to mechanics, engineers and certain manufacturers. Although geology appears in the title, its terms are not, by far, the major constituent of the book. Geological terms included are: some rocks and minerals, certain structural and economic terms, and some stratigraphic and chronologic terms. Most are concerned with, or most often encountered in connection with, mineral deposits. The entries are very conveniently arranged. Aside from economic geology, this book will be useful in libraries of geology, and as a second dictionary for the general geologist.

Malcolm P. Weiss

Philosophy of Atomic Physics. *Joseph Mudry.* Philosophical Library. 136 pp. $3.75.

This book is an attempt to present a coherent philosophical structure, not for layman or student but for "the professional analyst who may be in a favorable position of conceiving the various intrinsic truths so interpreted." The author seems to sense the fact that even these readers may not follow him easily so he states in his Preface that "Finally, but imperatively important, it must be impressed that the actual discernment or comprehension of the entire text, entails not merely one causal reading, but more to the contrary, at least two or three in order of grasping the essential points."

From this reviewer's point of view, ten readings might still not reveal any essential points. The author is a wordist, not a master of straight forward clear English, and he has presented his theme of dialeticalatomism in such fantastic language that one wonders how possibly his ideas could be well organized.

The author very properly expresses his gratitude to the firm which has published his book. Few readers will share that feeling. Thomas Bailey Aldrich once said "Who lacks the art to express his thought, I hold were little poorer if he lacked the thought." This seems to me to be a case of point, but, of course, I am just a layman.

THOMAS H. LANGLOIS

Introduction to Geology. *H. E. Brown, V. E. Monnett,* and *J. W. Stovall.* Ginn & Company, Boston. First Edition, 1958. viii+644+xx pp. $7.25.

Those interested in geology as a cultural course will appreciate this compound text in Physical and Historical Geology since it was written primarily for them. Because of this orientation, the treatment of subject matter is more panoramic than analytical.

Part I embraces the realm of Physical Geology and is so titled. Its chapters dealing with erosional processes and landforms are succinctly and clearly presented, strikingly well illustrated and abreast of the times factually. In contrast the chapters "Diastrophism and its Effects," "Mountains" and "Vulcanism," though descriptively accurate, are perhaps too insulated and conservatively treated. A discussion linking active mountain systems with the present Island Arcs (ignored in the text per se) would have been more effective.

Part II, "Historical Geology," includes a brief survey of the paleontologically important phyla and their development in conjunction with the unfolding of geologic events. All orthodox facts are touched lightly though vividly. New facts have been interwoven into the old throughout; especially in the sections on astronomy and anthropology.

All in all, the book forms a good conservative text for a Liberal Arts course in Geology.

JAMES E. CHRISTOPHER

Progress in Crystal Physics, Vol. 1 (Thermal, Elastic and Optical Properties). *R. S. Krishnan, et al.* S. Viswanathan (Central Arts Press), Madras. 1958. vi+198 pp. Rs. 20/-.

This work represents the collaboration of seven persons associated with The Indian Institute of Science at Bangalore, namely: R. S. Krishnan, P. T. Narasimhan, S. Ramaseshan, R. V. G. Sundara Rao, V. Sivaramakrishnan, R. Srinivasan, and K. Vedam.

For non-metallic single crystals, the experimental data are compiled, and present theories are discussed in chapters titled: (1) Thermal Expansion, (2) Thermal Conductivity, (3) Elastic Constants, (4) Photoelastic Effect, (5) Thermo-Optic Behavior, (6) Faraday Effect in Diamagnetic Crystals, and (7) Dielectric Properties of Ionic Crystals. An introduction discusses basic interrelations of physical measurement and crystal symmetry.

Inspection reveals that the tabulations of data are not complete. For example, four sets of elastic constants are given for pyrite, but these do not include two sets of constants that appear in the *Handbook of Physical Constants.* (Geol. Soc. Amer., 1942). The scope of the present compilation is broader, however, and includes such substances as ammonium dihydrogen phosphate.

DUNCAN MCDONNELL

Announcing the appearance of a new series of the Bulletins of The Ohio Biological Survey

This notice is to announce the appearance of a New Series of Bulletins of The Ohio Biological Survey. The first number in the new series is entitled "The Primeval Forests of a Periglacial Area in the Allegheny Plateau" by Dr. Janice C. Beatley with a check list of vascular plants by Floyd Bartley.

This bulletin of 182 pages is illustrated with 37 figures and a 7-color map insert. It may be purchased from The Ohio Biological Survey, 1885 Neil Avenue, The Ohio State University, Columbus 10, Ohio. List price of this number is $3.00.

The Ohio Biological Survey is an interinstitutional agency administered through The Ohio State University to foster research and publications concerning the State's flora and fauna. Twenty-four institutions including Ohio colleges, museums and park boards cooperate in this program.

Announcement

THE OHIO ACADEMY OF SCIENCE has just become the third state Academy of Science in the United States to establish an office of Permanent Executive Secretary. The new Executive Secretary, Mr. Kenneth B. Hobbs, has assumed his duties and Executive Offices of the Academy have been established in Columbus. The address is:

The Ohio Academy of Science
Executive Offices
505 King Avenue
Columbus 1, Ohio
Telephone: AXminster 9-9097

The offices are located on the third floor of the Administration Building, suite 309, at Battelle Memorial Institute. Battelle, which has always shown great interest in the same objectives as the Academy, has generously provided office space and equipment at no cost to the Academy. In addition, the personnel at Battelle have been most helpful in matters pertaining to the task of getting the offices ready for operation. Although credit for developing the idea of providing office space for the Academy at Battelle can not be given to any one individual, our special appreciation goes to Academy Member, Dr. Jack J. Bulloff, Applied Physics Division, who developed the idea from the beginning.

Most of you already know why the office of Permanent Executive Secretary has been established. However, we would like to reemphasize one of its more important aspects. It will serve Academy members by lending assistance whenever and wherever it is needed. The office can serve you better and more effectively if you will communicate with the Executive Secretary whenever you need assistance in your work or Academy business. Your suggestions are always welcome. You may prefer a personal visit to the office instead of a written communication, but whatever you do, write, telephone, or visit your Executive Offices and make use of its services which are available to you for the asking.

Administration Building at Battelle Memorial Institute, Columbus, Ohio, in which the new Executive Offices of The Ohio Academy of Science are located.

KENNETH B. HOBBS.